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# A Theory of Multitier Ecolabel Competition

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Carolyn Fischer, Thomas P. Lyon

**Abstract:** Ecolabels are widely used to inform markets about credence attributes of products. We present the first analysis of ecolabel competition that allows labels to have multiple tiers (e.g., silver/gold/platinum). For either an industry association or an NGO sponsor in autarky, binary labels are preferred when a large enough share of producers have a low cost of quality and when cost heterogeneity across firms is limited; multitier labels are preferred when a large enough share of producers have a high cost of quality and when cost heterogeneity is substantial. The NGO implements welfare-maximizing standards under certain conditions; the industry never does. When sponsors with differing objectives compete, the unique equilibrium involves multitier labels, with less environmental protection than the NGO in autarky would provide. The multitier equilibrium is robust to endogenous entry by producers.

**JEL Codes:** D82, L15, L31, Q50

**Keywords:** ecolabels, certification, vertical differentiation, credence goods, NGOs

GLOBAL ENVIRONMENTAL ISSUES such as biodiversity and climate change are increasingly important to citizens around the world but are extremely difficult for governments to address with standard policy tools. The globalization of trade and the need for international coordination on global issues make harmonized world standards

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for environmental problems unlikely in the foreseeable future. Global trade law also makes it difficult for governments to attempt to regulate attributes of production processes beyond their borders. In response, many groups (both industry trade associations and environmental advocacy groups) have put increasing effort into international market mechanisms involving ecolabeling (Steering Committee 2012).

Ecolabels can be of two types: binary or multitiered. Binary labels establish a threshold of performance and award a label to any product that meets or exceeds it. Binary labels include Forest Stewardship Council (FSC) certification in timber products and Marine Stewardship Council (MSC) certification in seafood, as well as Fair Trade, Rainforest Alliance, and Bird Friendly certifications, all competing in the coffee market. Multitier labels establish a “ladder” of graduated performance levels and award different labels depending on a product’s performance. Perhaps the best-known multitier label is the US Green Buildings Council’s Leadership in Energy and Environmental Design (LEED) certification for buildings, established in 1998, which offers certified, silver, gold, and platinum levels. LEED faces competition from a newer entrant, the Green Globes program, established in 2005 by the Green Building Initiative, which also offers four tiers that run from one to four “globes.” In addition, Sustainable Forestry Initiative (SFI) certification, an industry-driven competitor to FSC, allows multiple tiers since users can specify any percentage of certified content they desire, as long as they state it clearly as part of their labeling.

Ecolabels also differ according to the sponsor of the label, with some offered by non-governmental organizations (NGOs) with a mission of environmental advocacy, and others offered by industry trade associations. NGO labels include FSC and Rainforest Alliance, while industry-backed labels include Sustainable Forestry Initiative (SFI) certification for forest products and Green Globes for buildings.

Although there is a substantial theoretical literature on ecolabels, it has largely ignored the possibility of multitiered labels, the possibility of strategic competition between labels, and the different objectives of NGO and industry sponsors. Fischer and Lyon (2014) was the first paper to study strategic competition between labels and to allow different objectives for NGO and industry sponsors. The present paper examines when each of these types of sponsors prefers to offer a binary label as opposed to a multitier label and goes on to explore the nature of equilibrium when labels from both types of sponsors compete. We seek to characterize the nature of the ecolabels that are offered by each type of sponsor in equilibrium and to assess the impact of multitiered labels and of label competition on overall environmental protection.<sup>1</sup>

We study credence goods, for which consumers cannot discern product quality on their own, even after consumption, and hence rely on labels to provide information about quality. We build on the standard duopolistic model of vertical product differentiation, in which all consumers prefer higher-quality products but differ in their will-

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1. Li and van ‘t Veld (2015) explore similar issues under a quite different set of assumptions, as we explain in more detail below.

ingness to pay for quality. However, because markets in which ecolabeling is common typically have many small producers rather than a duopoly, we allow for two classes of price-taking firms, some with low costs of improving quality and some with high costs of doing so. A multitier label creates incentive compatibility constraints that require label sponsors to distort environmental standards if they wish to induce low-cost firms to choose higher levels of performance. Consequently, from the perspective of either industry profits or environmental performance, binary labels may be preferred to multitier labels.

Two different types of organization may sponsor labels: an NGO seeks to maximize environmental benefits, while an industry trade association seeks to maximize the aggregate profits of the industry. For either type of sponsor, labels can take one of three basic forms. First, a single stringent standard can be set that can only be achieved by low-cost firms. Second, a single weak standard can be set that can be met by all firms. Third, two separate standards can be set, with the standard for low-cost firms distorted by the need to ensure that they do not pool with the high-cost firms.

For either sponsor in autarky, the optimal label format depends upon the mix of high-cost and low-cost firms, and the magnitude of the cost gap between them. However, we demonstrate that when the labels compete using multitier labels there exists a unique equilibrium pair of standards, and competition always provides less environmental protection than would the NGO in autarky.

The remainder of the paper is organized as follows. Section 1 presents the basic model and its context within the literature, and exhibits the conditions for the existence of binary and multitiered labels. Section 2 characterizes the welfare-maximizing label structure and the structure of optimal ecolabels for the NGO and the industry in autarky. Section 3 presents the results for multitier competition between the two sponsors. Section 4 shows the existence of Pareto-improving cooperative solutions. Section 5 extends the model to allow for endogenously determined entry and shows that our results continue to hold at the equilibrium level of entry. Section 6 discusses our results in the context of the stylized facts about ecolabel proliferation, and section 7 concludes. Appendix A contains longer proofs, and an accompanying appendix B (available online) analyzes the case of binary labels.

## 1. MODEL SPECIFICATIONS AND CONTEXT

We formulate a model with heterogeneous consumer preferences for ecolabel characteristics and heterogeneous costs for meeting ecolabel standards, depending on a firm's type. The demand side of our model uses the standard vertical product differentiation framework, in which all consumers prefer greener products but differ in their willingness to pay for environmental quality.<sup>2</sup> The supply side of our model, however, makes some novel assumptions that depart from the standard vertical differentiation model.

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2. Mussa and Rosen (1978) originated this modeling framework. Unlike a representative consumer model (Fischer and Lyon 2014), this structure implies that the demand for higher-quality products depends on both their own price and the price of lower-quality substitutes.

In the canonical model, there are two firms with different costs of increasing product quality; the firms differentiate, with the high-cost firm offering a low-quality product and the low-cost firm offering a high-quality product and earning higher profits (e.g., Lehmann-Grube 1997). However, the actual markets in which ecolabeling is common—such as agriculture, forestry, and fisheries—typically have many small producers rather than a duopoly. Thus, in our model we allow for two classes of firms, some with low costs of improving environmental performance (“quality”) and some with high costs of quality, but with many small price-taking firms in each class. Initially we assume that the number of firms within each class is exogenously given, and we study the implications of varying the mix of these two classes of firms. In section 5, we relax this assumption and allow for endogenous entry.

Like many other papers, we treat environmental quality as a credence good, so consumers are unable to discern the environmental attributes of a product on their own, even after consumption. Hence they rely on ecolabels to provide information about these attributes. Two different types of organization may offer ecolabels: an NGO seeks to maximize environmental benefits, while an industry trade association seeks to maximize the aggregate profits of the industry.

Our focus on strategic ecolabel competition motivates some assumptions regarding the certification industry that depart from some related strands of the literature. One strand of the literature follows Lizzeri (1999), who assumes that certification bodies seek to maximize their own profits, which leads them to set low standards and extract all industry rents through high certification fees. In the case of ecolabels, however, this seems to be sharply at odds with reality, where certification bodies are often nonprofit organizations and chronically close to bankruptcy. Instead of assuming that certification bodies maximize profits, we assume that they costlessly set standards that serve the objectives of either NGOs or industry members. Another strand of the literature focuses on the imperfect nature of certification, allowing for Type I errors (incorrect rejection of a product that is truly green) and/or Type II errors (failure to reject a product that is not truly green). Hamilton and Zilberman (2006) pursue this approach in a setting with a monopolistic certification body and two quality options (green and brown) where sellers may engage in fraud, that is, they allow for Type II errors. Mason (2011) pursues the noisy certification approach in a setting with a monopolistic certification body and two quality options (green and brown), and allows for both Type I and Type II errors. Harbaugh et al. (2011) study competition between exogenously set standards enforced by error-prone auditors. Heyes et al. (n.d.) study competition between exogenously set standards when consumers must incur a cost to learn the meaning of a label. While we believe it would be of interest to model the certification industry in more detail, including the possibility of certification errors and the agency relationship between certification bodies and auditors (as in Lerner and Tirole 2006), we leave this task for future work, opting instead to focus on the implications of strategic competition between standard-setting bodies that have differing objectives in a setting where there is a continuum of possible quality options.

This paper builds on the prior work of Fischer and Lyon (2014), which was the first paper to study strategic competition between two certification bodies with differing objectives. That paper, however, allowed each certification body to set only binary standards, so it assumed away the issue that takes center stage here, namely, the incentives of certification bodies to choose between binary and multitiered standards. It also employed rather different models of demand and supply, using a simple representative consumer model based on that in Heyes and Maxwell (2004) and a continuum of firms with differing costs of quality. We believe the modeling choices we make in the present paper provide a better setting for exploring multitiered labels. The simpler treatment of the supply side of the model (two types instead of a continuum) allows us to obtain explicit results for strategic multitier competition in a more nuanced model of demand. At the same time, we maintain the focus on the competition between NGO-led and industry-led ecolabels. (It is worth noting that although we assume two types of firms instead of a continuum, our basic results for binary label competition are qualitatively similar to Fischer and Lyon [2014], providing assurance that our results are not an artifact of this modeling simplification. More details about this comparison can be found in n. 12 below.)

There are to our knowledge only two other papers that examine vertical quality competition between standards.<sup>3</sup> Poret (forthcoming) studies binary label competition between two NGOs with objective functions that differ in the emphasis they place on label stringency and quantity of labeled products sold. She finds that the two labels can coexist in the market only when their objectives are highly differentiated and their choices of quality are strategic substitutes. She also finds that competition causes the NGO with the more stringent standard to lower it, but increases overall environmental improvement. Like us, Li and van 't Veld (2015) study strategic competition between NGO and industry ecolabels in a context with heterogeneous consumer preferences. However, they make some very different assumptions that lead to very different results. Most importantly, they assume that all firms have the same marginal production cost of producing an environmentally friendly product. As a result, all firms are indifferent between labels of varying stringency, and the industry association has no preferences regarding competition or the number of tiers offered by labeling schemes as long as at least one standard is set at the level that maximizes the green market's size. The authors find that NGO labels and industry labels always coexist in the market. However, when they study competition between labels, they limit themselves to binary labels, as in Fischer and Lyon (2014). Thus, our paper is the first to obtain results on competition between certifiers offering multitiered labels.

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3. Heyes and Martin (2016) study competition between labels that choose an "issue" (a position on a circle) and then set label stringency; however, each label addresses a different issue, so labels do not compete on the vertical dimension within a given issue.

### 1.1. Consumers

We consider two quality levels for the ecolabel standards: a basic level,  $s^B$  and a more ambitious level  $s^A > s^B$ . To represent the demand for ecolabel stringency, let consumers have utility  $u = \mu s - p$ , with  $\mu \in [0, 1]$  distributed according to density function  $f(\mu)$ . Then we can find the consumer at  $\mu^B$  who is indifferent between buying the product with the basic ecolabel and not buying at all:

$$\mu^B s^B - p^B = 0.$$

Next we identify the consumer at  $\mu^A$  who is indifferent between the two qualities:

$$\mu^A s^A - p^A = \mu^A s^B - p^B.$$

Solving for these preference levels we have

$$\mu^B = \frac{p^B}{s^B} \quad (1)$$

and

$$\mu^A = \frac{p^A - p^B}{s^A - s^B}. \quad (2)$$

Assuming  $f(\mu)$  is uniform on  $[0, 1]$ , then  $f(\mu) = 1$ , and as shown in figure 1 there are three groups of consumers. Consumers with the lowest taste for quality do not buy an ecolabeled product, and their aggregate demand is

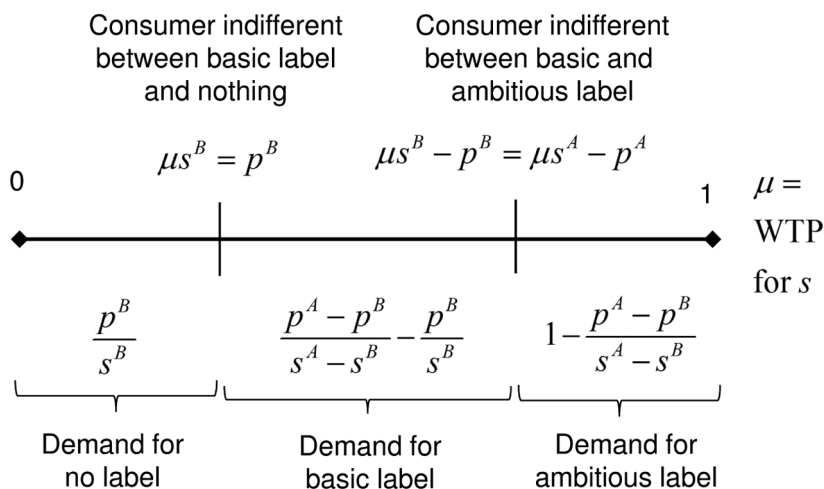


Figure 1. Consumer demand. WTP = willingness to pay

$$D^0 = \frac{p^B}{s^B}.$$

Consumers with the highest taste for quality purchase the high-quality product, and their aggregate demand is

$$D^A = 1 - \frac{p^A - p^B}{s^A - s^B}.$$

Finally, consumers with a moderate taste for quality purchase the low-quality product, and their aggregate demand is

$$D^B = \frac{p^A - p^B}{s^A - s^B} - \frac{p^B}{s^B} = \frac{s^B p^A - p^B s^A}{s^B (s^A - s^B)}.$$

Note that in the case of a single, binary label with standard  $s^U$  and price  $p^U$ , consumer demand is

$$D^U = 1 - \frac{p^U}{s^U}.$$

Figure 1 portrays the division of consumer demand among the labeled and unlabeled products.

## 1.2. Firms

On the supplier side of the market, there are  $N$  price-taking firms, each producing one unit of the product with environmental damage  $Z$ . Firms can take measures to reduce their environmental damages, with damages falling to  $Z - s$  if the firm undertakes measures of stringency  $s$ . We will limit our analysis to cases where  $s \geq 0$ .

The firms are of two types, based on their costs of meeting the label requirements. Two-type models are, of course, common in the literature on information economics and typically provide the main insights associated with continuous-type models but in much crisper form (Rasmusen 2006). However, the two-type assumption is also a plausible representation of the certification world. For example, Delmas et al. (2004) suggest that the cost of becoming an FSC-certified lumber supplier depends largely upon whether the supplier is already sophisticated enough to offer “whole system” home building solutions to buyers or not, a binary distinction.

For a firm of type  $i$ , the cost of adopting a label of stringency  $s^j$  is  $\theta^i (s^j)^2$ . Thus, costs are quadratic in label stringency and the marginal cost of quality is  $2\theta^i s^j$ . Profits for firm  $i$  pursuing label  $j$  are the revenues  $p^j$  minus these costs:

$$\pi^{ij} = p^j - \theta^i (s^j)^2.$$



There are  $N^A$  firms with low cost parameter  $\theta^A$  that are better suited to pursue the ambitious standard and  $N^B$  firms (having higher costs  $\theta^B > \theta^A$ ) that are better suited for the basic label. (We make the matching between firms and standards precise below.) Let  $N = N^A + N^B$ . Our market scale for the certified market is such that  $N < 1$ , since the distribution of consumers sums to 1.

### 1.3. Price Determination

If standards are set in such a way that the two types of firms prefer different labels, then in equilibrium supply equals demand, so that  $N^A = D^A$  and  $N^B = D^B$ . We can then work backwards to solve for prices as a function of the standards. First, we obtain the price for the basic standard. From  $N = D^A + D^B = 1 - p^B/s^B$ , we obtain

$$p^B = s^B(1 - N). \quad (3)$$

Note that this price is a function of the basic standard alone and does not depend on the ambitious standard.

Next, we solve for the price associated with the ambitious standard. Setting  $N^A = D^A$  and substituting in for  $p^B$  we obtain

$$p^A = s^A(1 - N^A) - s^B N^B. \quad (4)$$

Note that the price of the ambitious label is decreasing in the standard for the basic label, since they compete with one another. Now we can compute profits. The profit of a high-cost firm meeting standard  $s^B$  is

$$\pi^{BB} = p^B - \theta^B (s^B)^2 = s^B(1 - N) - \theta^B (s^B)^2$$

and the profit of a low-cost firm meeting standard  $s^A$  is

$$\pi^{AA} = p^A - \theta^A (s^A)^2 = s^A(1 - N^A) - s^B N^B - \theta^A (s^A)^2.$$

### 1.4. Conditions for a Multitier Equilibrium

The foregoing discussion assumes that the standards are such that a separating equilibrium exists in which the two types of firms prefer different labels. To characterize when this occurs, let us define the maximum single standard (i.e., when the other standard is absent; subscript  $E$  indicates that this is the most environmentally friendly standard possible) that generates nonnegative profits for each firm type:

$$\begin{aligned} s_E^B &\equiv (1 - N)/\theta^B; \\ s_E^A &\equiv (1 - N^A)/\theta^A > s_E^B. \end{aligned}$$

Other useful points of reference are the single standards that maximize profits for each individual type (subscript  $\pi$  indicates profit maximization):

$$\begin{aligned}s_{\pi}^B &\equiv s_E^B/2; \\ s_{\pi}^A &\equiv s_E^A/2 > s_{\pi}^B.\end{aligned}$$

For each firm type there are two constraints: (1) *individual rationality* (IR), which requires that profits be nonnegative, and (2) *incentive compatibility* (IC), which requires that profits be higher with the firm's own standard than with the other type's standard, given the prevailing prices.

In a multitier equilibrium, for low-cost firms to adopt the ambitious standard, the IR constraint requires  $\pi^{AA} \geq 0$ , or  $s^A \leq s_E^A$ , and the IC constraint for an individual type A firm ("ICA constraint") requires  $\pi^{AA} \geq \pi^{AB} = p^B - \theta^A (s^B)^2$ , which reduces to

$$s^A \leq s_{ICA}^A(s^B) \equiv s_E^A - s^B,$$

implying a one-to-one trade-off as  $s^B$  is increased.

In a similar fashion, in order for high-cost firms to adopt the basic standard, the IR constraint requires  $\pi^{BB} \geq 0$  or  $s^B \leq s_E^B$  and the IC constraint for an individual type B firm ("ICB constraint") requires  $\pi^{BB} \geq \pi^{BA} = p^A - \theta^B (s^A)^2$ , which reduces to

$$s^B \geq s_{ICB}^B(s^A) \equiv (1 - N^A)/\theta^B - s^A.$$

It will sometimes be convenient to write this in terms of an "exclusionary standard"  $s_x^A(s^B)$  that is just high enough to exclude a high-cost firm from opting for the ambitious standard, given  $s^B$ :

$$s^A \geq s_x^A(s^B) \equiv (1 - N^A)/\theta^B - s^B.$$

Note that if the high-cost firms have nonnegative profits with the basic standard, then a fortiori the low-cost firms would have positive profits with that standard ( $\pi^{AB} > \pi^{BB} \geq 0$ ); if the incentive compatibility constraint is met for the low-cost firms, then their individual rationality constraint is automatically satisfied, that is,  $\pi^{AA} \geq \pi^{AB} > \pi^{BB} \geq 0$ . Thus, in an equilibrium with two standards, four constraints must be met:

1.  $0 \leq s^B \leq s^A$ ,
2.  $s^B \leq s_E^B$ ,
3.  $s^B \geq s_{ICB}^B(s^A)$ ,
4.  $s^A \leq s_{ICA}^A(s^B)$ .

It will be helpful in later sections to know whether the ICA and ICB constraints can both bind simultaneously, as is addressed in the following lemma.

**Lemma 1:** The ICA and ICB constraints cannot bind simultaneously.

*Proof:* If  $s^A = s_{ICA}^A(s^B) = s_E^A - s^B$ , then  $s^B = (1 - N^A)/\theta^A - s^A > (1 - N^A)/\theta^B - s^A = s_{ICB}^B(s^A)$ . Similarly, if  $s^B = s_{ICB}^B(s^A) = (1 - N^A)/\theta^A - s^A$ , then  $s_E^A - s^B = (1 - N^A)/\theta^A - (1 - N^A)/\theta^A + s^A > s^A$ . QED

## 2. AUTARKY POLICIES

We begin our analysis by characterizing the welfare-maximizing set of ecolabels, after which we characterize the preferred labeling standards when each certifying body can set them on their own, without threat of competition. We show that for each label sponsor—social planner, NGO, or industry—a simple binary label is preferred to a multitiered label under certain conditions on industry structure. However, the circumstances under which one or the other is preferred differ greatly depending on the objectives of the label sponsor.

Since the NGO maximizes environmental protection and the industry maximizes aggregate profits, one might expect the welfare-maximizing set of standards to fall strictly in between the NGO and the industry standards. However, as we will show, there is a range of conditions under which the NGO actually implements the welfare-maximizing set of standards.

### 2.1. Social Welfare Maximum

Social welfare consists of the sum of consumer surplus, producer surplus, and environmental gains. Consumer surplus is given by

$$\begin{aligned} CS(s^A, s^B) &= \int_{\mu^B}^{\mu^A} (\mu s^B - p^B) f(\mu) d\mu + \int_{\mu^A}^1 (\mu s^A - p^A) f(\mu) d\mu. \\ &= \frac{N^B(2 - N - N^A)}{2} s^B + \frac{N^A(2 - N^A)}{2} s^A - p^B N^B - p^A N^A, \end{aligned}$$

where we are making use of (1), (2), (3), (4), and our assumption that  $f(\mu)$  is uniform. With a single basic standard  $CS(s^B, s^B) = N[2 - N]s^B/2 - Np^B$  and with a single ambitious standard  $CS(s^A, 0) = N^A(2 - N^A)s^A/2 - p^A N^A$ .

Environmental gains are

$$G(s^A, s^B) = N^A s^A + N^B s^B,$$

and industry profits are

$$\begin{aligned}\Pi(s^A, s^B) &= p^A N^A + p^B N^B - N^A \theta^A (s^A)^2 - N^B \theta^B (s^B)^2 \\ &= N^A \left( s^A (1 - N^A) - s^B N^B - \theta^A (s^A)^2 \right) + N^B \left( s^B (1 - N) - \theta^B (s^B)^2 \right).\end{aligned}$$

In the remainder of the paper, we will sometimes suppress the dependence of these measures on  $s^A$  and  $s^B$  when there is no risk of confusion.

A social planner would choose  $s^A$  and  $s^B < s^A$  to maximize welfare  $W = CS + G + \Pi$ , subject to the IC and IR constraints. Simplifying, welfare is consumer utility net of costs, plus environmental gains:

$$\begin{aligned}W &= \frac{N^B(2 - N - N^A)}{2} s^B + \frac{N^A(2 - N^A)}{2} s^A - N^A \theta^A (s^A)^2 - N^B \theta^B (s^B)^2 \\ &\quad + N^A s^A + N^B s^B.\end{aligned}$$

This welfare function is strictly increasing in  $s^A$  up to and beyond  $s_E^A$ .<sup>4</sup> Thus, the planner will want to set the ambitious standard as high as possible, meaning  $s^{A*} = s_E^A$  for a single ambitious standard and  $s^{A*} = s_{ICA}^A$  for a differentiated multitier standard. Since the ICA constraint binds, the ICB constraint cannot.

Similarly, given  $s^A$ , welfare is strictly increasing in  $s^B$  up to and beyond  $s_E^B$ .<sup>5</sup> Thus, the planner will also want to set the basic standard as high as possible. This means  $s^{B*} = s_E^B$  for a single basic standard. For a multitier standard with the ICA constraint binding, the planner will need to balance the benefits of raising  $s^B$  with the costs of lowering  $s^A$ .

The following proposition characterizes the structure of the welfare-maximizing standard. The proof begins by showing that the incentive compatibility constraint for the low-cost firms always binds, so the other constraints do not. Hence, for a multitiered solution, the problem simply becomes choosing the optimal basic standard, which can be shown to be

$$s_W^B = \frac{N(4 - N) - 2N^A(2 + N^A)}{4N\bar{\theta}},$$

where  $\bar{\theta} \equiv (N^A \theta^A + N^B \theta^B)/N$ . The remainder of the analysis involves properly accounting for the relevant constraints and involves the following expressions:<sup>6</sup>

4. Evaluating  $\partial W / \partial s^A = N^A(4(1 - s^A \theta^A) - N^A)/2$  at  $s^A = s_E^A$  yields  $3(N^A)^2/2 > 0$ .
5. Evaluating  $\partial W / \partial s^B = N^B(4(1 - s^B \theta^B) - N^B)/2$  at  $s^B = s_E^B$  yields  $(3N - N^A)(N - N^A)/2 > 0$ .
6.  $N_W^A = \sqrt{1 + 2N - N^2/2} - 1$ ;  $\Theta_{ICA} = (1 - N^A)/(2(1 - N))$ ;  $\Theta_W^{MT1} = (3N^2 - 2N^A(2N + N^A))/(4N^A(1 - N))$ ;  $\Theta_W^{Binary} = (1/2) + ([N(2 + N) - \chi]/[4N^A(1 - N)])$ , where  $\chi = \sqrt{N^4 + 4N^2(1 - N^A + (N^A)^2 + N(1 - N^A)) + 8N^A((N^A)^2(1 + N^A) + N(1 - N^A)) - 12(N^A)^2}$ ; and  $\Theta_W^{MT2}$  must be solved numerically.

- $\Theta_{ICA}$  (where  $s_{ICA}^A(s_E^B) = s_E^B$ ),
- $\Theta_W^{MT1}$  (where  $s_W^B = s_E^B$ ),
- $\Theta_W^{MT2}$  (where  $W(s_E^B, s_E^B) = W(s_{ICA}^A(s_W^B), s_W^B)$ ),
- $\Theta_W^{Binary}$  (where  $W(s_E^B, s_E^B) = W(s_E^A, 0)$ ), and
- $N_W^A$  (defining where  $s_W^B = 0$ ).

**Proposition 1:** The welfare-maximizing standard depends upon the market share of low-cost firms in the certified market and their cost advantage relative to high-cost firms. A single standard is optimal if the number of low-cost firms in the certified market is high ( $N^A > N_W^A$ ): it will be an ambitious standard of  $\{s_E^A, 0\}$  if costs are sufficiently different ( $\theta^A/\theta^B < \Theta_W^{Binary}$ ) and a single basic standard of  $\{s_E^B, s_E^B\}$  otherwise. If the number of low-cost firms in the certified market is low ( $N^A < N_W^A$ ) then  $s^B > 0$  and  $s^A = \max[s_{ICA}^A(s^B), s^B]$ . In this case, if the cost advantage of the low-cost firms is large ( $\theta^A/\theta^B < \Theta_{ICA}$  and  $\theta^A/\theta^B < \Theta_W^{MT1}$ ) then a multitier standard of  $\{s_{ICA}^A(s_E^B), s_E^B\}$  is optimal. If the cost advantage of the low-cost firms is in the range  $\Theta_W^{MT1} < \theta^A/\theta^B < \Theta_W^{MT2}$ , then a multitier standard with  $s^B = s_W^B \in (0, s_E^B)$  holds. Otherwise, a single basic standard of  $\{s_E^B, s_E^B\}$  is optimal.

*Proof:* See appendix A. QED

Intuitively, the single ambitious standard is preferred when low-cost firms dominate the certified market, and it is set at the highest level possible consistent with participation by the low-cost firms. The exception is when cost differences are small enough that a small reduction in the standard to the maximum achievable by the high-cost firms brings in more benefits with full participation. When high-cost firms dominate the certified market, a multitier standard is optimal unless the two types of firms have similar costs, in which case a differentiated standard cannot be supported and a single basic standard is used. As the share of ambitious firms gets larger, it may be optimal to increase the differentiation among standards, asking less than the maximum from the high-cost firms in order to ask more from the low-cost firms.

Figure 2 presents the welfare-optimal standards for the case of  $N = 1/2$ ; results are qualitatively similar for smaller values of  $N$ . When low-cost firms dominate the certified market (i.e., when  $N^A/N > N_W^A/N = .7386$ ), a single ambitious standard is preferred if costs are sufficiently differentiated ( $\theta^A/\theta^B < \Theta_W^{Binary}$ , shown in the dark gray area). When the mix of low-cost and high-cost firms is more balanced and low-cost firms have a significant cost advantage (i.e.,  $\theta^A/\theta^B < \Theta_W^{MT2}$ ) a multitier standard with an optimized  $s_W^B$  is preferred (the white area). When high-cost firms dominate the market and low-cost firms have enough of a cost advantage (i.e.,  $\theta^A/\theta^B < \min[\Theta_{ICA}, \Theta_W^{MT1}]$ ), the constrained multitier standard of  $(s_E^A - s_E^B, s_E^B)$  is chosen (as seen in the light gray area). Regardless of the mix of firms, if the cost differential between the two types is

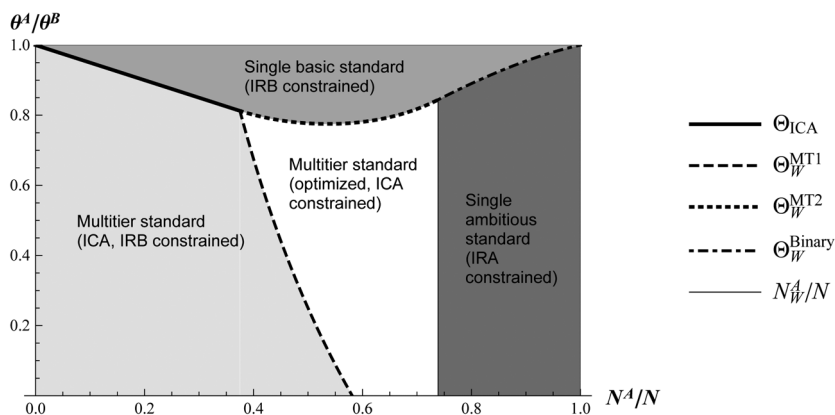


Figure 2. Welfare optimum ( $N = 1/2$ )

sufficiently small, then a single basic standard is optimal (shown in the medium gray area).

As the size of the certified market grows larger, the region where the single basic standard is preferred shrinks and eventually disappears altogether. Figure 3 presents the case of  $N = 2/3$ . The basic logic of the previous figure remains, but here the single basic standard is never optimal. A single ambitious standard is optimal when low-cost firms dominate, an interior multitier standard is optimal when the mix of low-cost and high-cost firms is intermediate, and a constrained multitier standard of  $(s_E^A - s_E^B, s_E^B)$  is optimal if high-cost firms dominate.

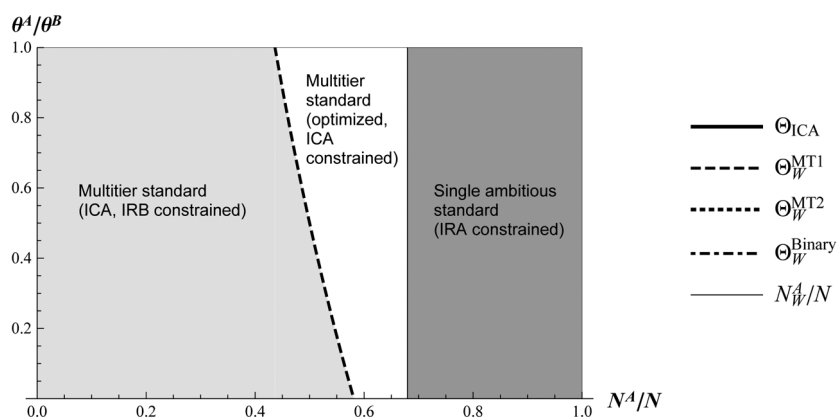


Figure 3. Welfare optimum ( $N = 2/3$ )

## 2.2. NGO Standards

The NGO's objective is to maximize total environmental gains:

$$G = N^A s^A + N^B s^B.$$

To maximize  $G$  the NGO wants to set both standards as high as possible, subject to the individual rationality and incentive compatibility constraints (that  $s^B \leq s_E^B$  and  $s^A \leq s_{ICA}^A = s_E^A - s^B$ ). Thus, there are three options for the pair  $\{s^A, s^B\}$ :<sup>7</sup>

1.  $\{s_E^A, 0\}$ , a single ambitious standard that can only be met by low-cost firms;
2.  $\{s_E^A - s_E^B, s_E^B\}$ , a multitier standard; or
3.  $\{s_E^B, s_E^B\}$ , a single basic standard in which both types participate.

These bear a strong resemblance to the set of possible welfare optima. In particular, the incentive compatibility constraint binds at an interior solution. Intuitively, the first option is chosen when the NGO does not wish to dilute the ambitious standard (which is necessary to meet the ICA constraint) by offering a lower-tiered standard. The second, multitier strategy requires market conditions that support a differentiated standard (namely, a large enough cost differential). The third strategy of a single basic standard occurs when the multitier standard is not supported and the NGO prefers this binary standard over the ambitious one.

We present the NGO's optimal standard in the next proposition.

**Proposition 2:** The NGO's optimal standard in autarky depends upon the share of the overall market that is certified, the market share of the low-cost firms, and the cost advantage of the low-cost firms. If less than  $2/3$  of the market is certified ( $N < 2/3$ ) and the majority of firms have low costs ( $N^A/N < 1/2$ ), then the NGO prefers a single ambitious standard of  $s_E^A$  if low-cost firms have a large cost advantage ( $\theta^A/\theta^B < \Theta_N^{\text{Binary}}$ ) and a single basic standard of  $s_E^B$  otherwise. If less than  $2/3$  of the market is certified and the majority of firms have high costs, then the NGO prefers a multitier standard of  $(s_{ICA}^A(s_E^B), s_E^B)$  if low-cost firms have a large cost advantage ( $\theta^A/\theta^B < \Theta_{ICA}$ ) and a single basic standard of  $(s_E^B, s_E^B)$  otherwise. If at least  $2/3$  of the market is certified, then the NGO prefers a single ambitious standard of  $s_E^A$  if the majority of firms have low costs, and a multitier standard of  $(s_{ICA}^A(s_E^B), s_E^B)$  otherwise.

*Proof:* See appendix A. QED

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7. Note that the NGO would be happy to have the high-cost firm want to adopt the more ambitious standard, so the  $s_{ICB}^B$  constraint is not a concern. Note also that the gains are linear in abatement and recall that  $\partial s_{ICA}^A / \partial s^B = -1$ , so there can be no interior solution with  $0 < s^B < s_E^B$  and  $s^A = s_{ICA}^A$ .

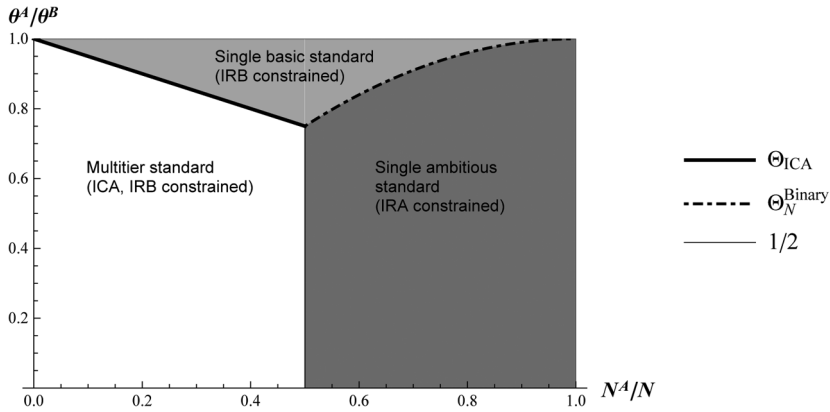


Figure 4. NGO optimum ( $N = 1/2$ )

The possible equilibria are illustrated graphically in figures 4 and 5, which show how the set of equilibria changes as the ratio  $N^A/N$  increases. In particular, we illustrate separately the cases with three equilibria (we show the example of  $N = 1/2$ , but the figure is qualitatively similar for any  $N < 2/3$ ) and with two equilibria (when  $N \geq 2/3$ ). The reason for the dependence on  $N$  is that the boundary conditions on  $\theta^A/\theta^B$  determining when a single basic standard is preferred to the alternatives change with  $N$ .

The optimal NGO label for the case where  $N = 1/2$  is illustrated in figure 4. When both types of firms have similar costs, a single basic standard that pushes the high-cost firms to their participation constraint is used. When low-cost firms dominate the certified market and have a more substantial cost advantage, a single ambitious standard that pushes the low-cost firms to their participation constraint is preferred. When

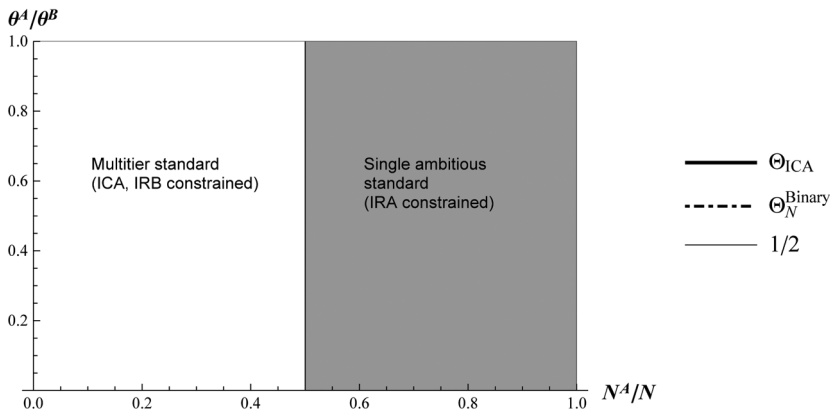


Figure 5. NGO optimum ( $N = 2/3$ )



high-cost firms dominate the certified market but have significantly higher costs than the type A firms, a multitier standard is used in which the high-cost firms are at their participation constraint and the low-cost firms are at their incentive constraint.

As mentioned above, if overall industry size is large enough, the NGO's strategy shifts distinctly. As the number of firms in the certified market grows, the value to the NGO of setting the single basic standard diminishes until at  $N \geq 2/3$ , it is dominated by one of the two other options. This case is illustrated in figure 5, where the border lines for  $\Theta_{ICA}$  and  $\Theta_N^{\text{Binary}}$  are no longer visible. Now the NGO simply chooses between  $(s_E^A, 0)$  and  $(s_{ICA}^A(s_E^B), s_E^B)$ . The multitier standard dominates the single ambitious standard when  $N^A < N/2$ .

### 2.3. Industry Standards

Consider now the industry's behavior when it is free to set its own standards without competition from the NGO. The industry trade association's objective is to maximize the total profits of all firms:

$$\Pi = N^A \left( s^A(1 - N^A) - s^B N^B - \theta^A (s^A)^2 \right) + N^B \left( s^B(1 - N) - \theta^B (s^B)^2 \right).$$

As was true for the NGO, the industry has three basic options for the pair  $\{s^A, s^B\}$ :

1.  $\{s^A, 0\}$ , a single ambitious standard that can only be met by low-cost firms;
2.  $\{s^A, s^B\}$ , a multitier standard; or
3.  $\{s^B, s^B\}$ , a single basic standard in which both types participate.

Note that, unlike the case with the social planner or the NGO as a label sponsor, there is no guarantee that the low-cost firms' incentive compatibility constraint binds. We begin our analysis of this case by showing that the industry, unlike the other two sponsors, never wants to have all firms certify to a single basic standard.

**Lemma 2:** In autarky, the industry never prefers an equilibrium in which both firm types certify to the same standard.

*Proof:* Consider a standard in which both types certify to the single basic standard  $s^B$ . With both types participating, joint profits are

$$\Pi_{SB} = N \left( s^B(1 - N) - \bar{\theta} (s^B)^2 \right),$$

where  $\bar{\theta} \equiv (N^A \theta^A + N^B \theta^B)/N$ . Taking the first-order condition, we solve for

$$s_{\Pi}^B = \frac{(1 - N)}{2\bar{\theta}}. \quad (5)$$

However, the industry can necessarily raise profits for both types of firms if it offers  $\{s_\pi^A, s_\pi^B\}$ . High-cost firms prefer  $s_\pi^B$  to  $s_\pi^A$ , and their profits are unaffected by the ambitious standard. Low-cost firms prefer  $s_\pi^A > s_\pi^B$ , and they also prefer that high-cost firms face a standard  $s_\pi^B < s_\pi^A$ , since a lower standard for the B firms raises prices for A firms. To the extent that the industry then deviates from  $\{s_\pi^A, s_\pi^B\}$ , it must be that it further raises joint profits. QED

Thus, the industry always chooses either a single ambitious standard that excludes the high-cost firms or a multitier standard. A single ambitious standard that cannot be met by the type B firms and maximizes the profits of the low-cost firms yields industry profits of

$$\Pi_{SA} = N^A \left( s^A(1 - N^A) - \theta^A (s^A)^2 \right).$$

If the industry chooses a single ambitious standard, it must take into account the ICB constraint to ensure that it does not inadvertently set a single basic standard that both types of firms can meet. In other words, it must choose between the profit-maximizing standard for ambitious firms,  $s_\pi^A$ , and the exclusionary standard that keeps the high-cost firms indifferent to no certification,  $s_x^A(0)$ ,<sup>8</sup> where

$$s_x^A(0) = \frac{(1 - N^A)}{\theta^B}.$$

A bit of calculation shows that the single ambitious standard is set at  $s_\pi^A$  if  $\theta^A/\theta^B < 1/2$  and at  $s_x^A(0)$  if  $\theta^A/\theta^B > 1/2$ .<sup>9</sup>

The industry's other option is a multitier standard. Interestingly, the combination comprising the two standards that are optimal for the two types of firms individually is never the optimal multitier strategy for the industry. The logic is similar to that in tra-

8. For a high-cost firm to be unwilling to participate in the ambitious standard, it must be that  $p^A - \theta^B (s^A)^2 < 0$ . If this condition holds for  $s_\pi^A$  (and the associated  $p^A = s_\pi^A(1 - N^A)$  that would obtain if no B's participated), then if the industry opts for the ambitious standard it will simply choose  $s_\pi^A$ . On the other hand, if  $s_\pi^A(1 - N^A) - \theta^B (s_\pi^A)^2 > 0$ , then the industry must raise the ambitious standard above  $s_\pi^A$  if it wants to exclude participation by high-cost firms. In the absence of a basic standard, the ambitious standard that just leaves the profit of a high-cost firm at zero (given that  $s^B = 0$ ) is  $s_x^A(0)$ . Note that  $s_x^A(0) = (1 - N^A)/\theta^B > (1 - N)/\theta^B = s_E^B$ . The difference exists because  $s_E^B$  is the standard at which high-cost firms earn zero profits if all of them certify to the standard, whereas  $s_x^A$  is the standard at which a single high-cost firm earns zero additional profits if it is the only one to certify to the ambitious firms' standard.

9. It is easy to see that  $s_x^A > s_\pi^A$  if  $(1 - N^A)/\theta^B > (1 - N^A)/2\theta^A$ , or  $\theta^A/\theta^B > 1/2$ . Thus, if the industry chooses a single ambitious standard it is set at  $s_\pi^A$  if  $\theta^A/\theta^B < 1/2$  and  $s_x^A(0)$  if  $\theta^A/\theta^B > 1/2$ .

ditional vertical differentiation models: profit maximization creates pressures to distort the basic standard downward in order to relax price competition (Shaked and Sutton 1982; Ronnen 1991).

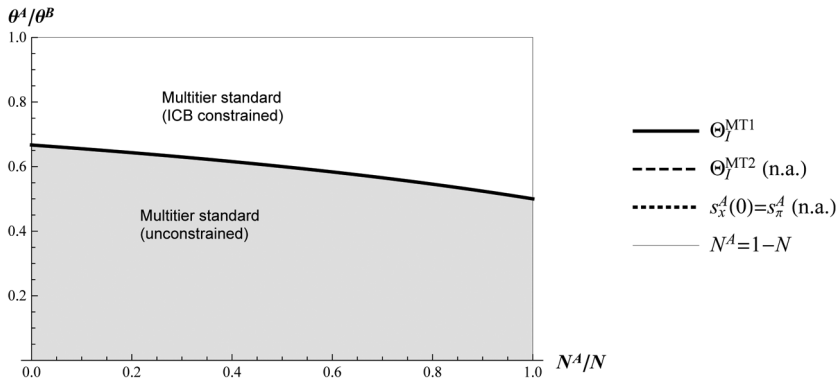
Thus, in the industry autarky case, the only relevant constraints regard the basic standard. Not only can it not fall below zero, but the ICB constraint may also limit how much the basic standard can be lowered, and also require the ambitious standard to rise to maintain separation. If the ICB constraint does not bind, the low-cost firms will get their unconstrained profit-maximizing standard; as shown in lemma 1, if the ICB constraint does bind, the ICA constraint cannot. Neither IR constraint will bind, since the standards are strictly below their maximums.

Proposition 3 characterizes the industry's optimal strategy in autarky, making use of the following threshold values:

- $\Theta_I^{MT1} = (1 - N^A)/(1 + N^B)$ , the relative cost at which the ICB constraint is just nonbinding with a multitier standard ( $\lambda_{ICB} = 0$ ); and
- $\Theta_I^{MT2} = 1 - N(1 - N)/(2(1 - N^A)N^A)$ , the relative cost at which the ICB-constrained interior solution has no basic standard ( $s_I^B = 0$ ).
- $(s_x^A(0) = s_\pi^A)$ , which defines the relative cost at which the exclusionary standard just equals the profit-maximizing standard for the ambitious firms;
- $N^A = 1 - N$ , the market share at which the unconstrained basic standard is nonpositive ( $s_\pi^B - N^A/(2\theta^B) = 0$ ).

**Proposition 3:** The industry's optimal standard in autarky depends upon the market share of low-cost firms and the cost advantage of low-cost relative to high-cost firms. If low-cost certified firms have a smaller market share than uncertified firms ( $N^A < 1 - N$ ), the industry prefers a multitier standard. In this case, if low-cost firms have a large cost advantage ( $\theta^A/\theta^B < \Theta_I^{MT1}$ ), then the industry prefers a multitier standard of  $(s_\pi^A, s_\pi^B - (N^A/2\theta^B))$ , but if low-cost firms have a small cost advantage ( $\theta^A/\theta^B > \Theta_I^{MT1}$ ), then the industry prefers a multitier standard of  $(s_\pi^A + (\lambda_{ICB}/2N^A\theta^A), s_{ICB}^B)$ . If low-cost certified firms have a larger market share than uncertified firms ( $N^A > 1 - N$ ) and their cost advantage is large ( $\theta^A/\theta^B < 1/2$ ), then the industry prefers a single ambitious standard of  $(s_\pi^A, 0)$ . If low-cost certified firms have a larger market share than uncertified firms and their cost advantage is moderate ( $\theta^A/\theta^B \in [1/2, \Theta_I^{MT2}]$ ), then the industry prefers a single ambitious standard of  $(s_x^A, 0)$ . If low-cost certified firms have a larger market share than uncertified firms and their cost advantage is small ( $\theta^A/\theta^B \in (\Theta_I^{MT2}, 1]$ ), then the industry prefers a multitier standard of  $(s_\pi^A + (\lambda_{ICB}/2N^A\theta^A), s_{ICB}^B)$ .

*Proof:* See appendix A. QED

Figure 6. Industry optimum ( $N = 1/2$ )

The optimal standards are illustrated in figures 6 and 7. Note that the ambitious standard is always set at or above its autarkic profit-maximizing level, while the basic standard is always distorted downward from its individually profit-maximizing level in order to reduce competition with the ambitious firms.

Figure 6 presents the case of  $N = 1/2$ , so  $N^A = (1 - N)$  at  $N^A/N = 1$ . In this case (and for any  $N < 1/2$ ), the industry always chooses a multitier standard, and the only question is whether the ICB constraint is binding. For  $\theta^A/\theta^B < \Theta_I^{MT1}$ , the ICB does not bind and for  $\theta^A/\theta^B > \Theta_I^{MT1}$  it does. Although  $\Theta_I^{MT2}$  and the curve where  $s_x^A(0) = s_\pi^A$  are listed in the legend, they are not applicable for these parameter values, as indicated by the “n.a.” in parentheses beside them.

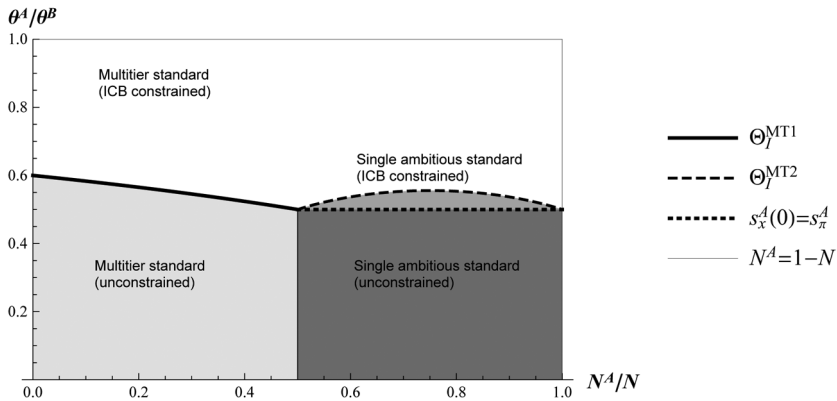
Figure 7. Industry optimum ( $N = 2/3$ )

Figure 7 presents the case of  $N = 2/3$ , so  $N^A = (1 - N)$  at  $N^A/N = 1/2$ . As lemma 2 stated previously, the industry association never wants to set a single standard to which both types would adhere. However, as the figure shows, if there are enough ambitious types and costs are sufficiently dispersed, the industry may prefer to set only a single ambitious standard, which it does to avoid eroding any profits for the low-cost firms, even with a modest basic standard for the high-cost firms. If the ambitious market segment is larger than the uncertified segment, and the A firms have substantially lower costs than the B firms, then the industry sets a single ambitious standard that only the A firms can meet. When  $\theta^A/\theta^B < 1/2$ , the industry is unconstrained and this standard is  $s_\pi^A$ ; for a small range where  $\theta^A/\theta^B > 1/2$ , the industry raises the ambitious standard above  $s_\pi^A$  to exclude the high-cost firms. Otherwise the industry offers a multitier label that is constrained by the ICB requirement. If the ambitious segment is smaller than the uncertified segment but costs are sufficiently different, then the basic standard is  $s^B = s_\pi^B - (N^A/2\theta^B)$ ; otherwise the industry offers a multitier label that is constrained by the ICB requirement.

## 2.4. Comparing Autarky Labels

In this section, we first compare the nature of the NGO and industry labeling schemes and then compare each of them to the welfare-maximizing labels. The labeling schemes differ in terms of the structure of the label, the stringency of standards, and the number of firms that choose to participate in the certified market.

### 2.4.1. Comparing NGO and Industry Labels

In terms of label structure, the use of binary labels differs across the two label sponsors. One notable difference is that the industry never offers a binary label that attracts both types of firm, as lemma 2 showed. Another difference is that if the size of the certified market is not too great ( $N \leq 2/3$ ), the NGO offers a binary label for a wider range of parameter values than does the industry.<sup>10</sup> For example, comparing figures 4 and 6 reveals that when  $N = 1/2$  the NGO often prefers a binary standard when low-cost firms have a large market share, but the industry never does. Similarly, comparing figures 5 and 7 shows that when  $N = 2/3$  the NGO always prefers a binary standard when  $N^A/N > 1/2$  but the industry only does when in addition  $\theta^A/\theta^B < \Theta_I^{MT2}$ .

In terms of stringency, the NGO's single ambitious standard is always higher than the industry's ambitious standard when  $s_N^A = s_E^A$ . Moreover, if the industry is not con-

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10. However, when the certified market becomes very large ( $N > 2/3$ ), the comparison is ambiguous. On one hand, the NGO offers a binary label while the industry offers a multitier label if the cost advantage of the low-cost firms is small ( $\theta^A/\theta^B > \Theta_I^{MT2}$ ). On the other hand, the industry offers a binary label while the NGO offers a multitier label if the cost advantage of the low-cost firms is great ( $\theta^A/\theta^B < \Theta_I^{MT2}$ ) and low-cost firms are less than half of the certified market ( $N^A < N/2$ ).

strained, then the NGO's ambitious standard is higher than the industry's. However, the following lemma shows that under some conditions the industry can set a higher ambitious standard.

**Lemma 3:** The industry may set a more stringent ambitious standard than the NGO.

*Proof:* This possibility occurs when both organizations want a multitier standard and  $\lambda_{ICB}/(2N^A\theta^A) > s_E^A - s_E^B - s_\pi^A$ . Since the stringency of the ICB constraint increases monotonically in  $\theta^A/\theta^B$ , we evaluate the standards at  $\theta^A/\theta^B = 1$  and find  $s_I^{A*} - (s_E^A - s_E^B) = (1 - N)/2\theta^B > 0$ . Such an outcome is also possible when the NGO sets a basic standard and  $\lambda_{ICB}/(2N^A\theta^A) > s_E^B - s_\pi^A$ . Consider the case where  $s_E^B = s_\pi^A$ , so the NGO is indifferent between the basic and multitier standard. If the ICB constraint is binding, then the industry will set an ambitious standard above  $s_\pi^A$ . QED

Thus, as the cost differences get small, the NGO may set a lower ambitious standard than the industry, in order to maintain a higher basic standard, while industry sets a higher ambitious standard in order to keep its basic standard low. This possibility can be observed in figures 4 and 6 for the case when  $N = .5$ . The borderline between the basic and multitier standards for the NGO lies within the region of constrained multitier standards for the industry, and close to this borderline the NGO's ambitious standard is weaker than that of the industry.

In addition, the industry may set a more stringent standard for the high-cost firms than does the NGO. In particular, there are parameter values for which the NGO sets an ambitious binary label (which implicitly sets  $s_N^B = 0$ ) but the industry sets a multitiered label with  $s_I^B > 0$ .

In terms of participation, the industry tends to attract a greater number of firms to participate in labeling than does the NGO. This occurs for any parameter values that lead the NGO to set a binary standard but lead the industry to set a multitier standard. However, as the following lemma shows, the opposite is also possible.

**Lemma 4:** The NGO may attract more participation than the industry if the total certified market size is large enough.

*Proof:* The industry always garners as much or more participation except in the case where the industry wants a single ambitious label, while the NGO prefers a multitier label. The industry has a single ambitious label when  $N^A > 1 - N$  and  $\theta^A/\theta^B < 1/2$  or  $\theta^A/\theta^B < \Theta_I^{MT2}$ . The NGO sets a multitier or single basic label if  $N^A < N/2$  or  $\theta^A/\theta^B > \Theta_N^{Binary}$ . These two situations can thus occur if  $N/2 > N^A > 1 - N$ , which requires  $N > 2/3$ . By proposition 2, the NGO will not set

a single basic standard in this range, but rather the multitier standard. Thus, when  $N > 2/3$  and  $\theta^A/\theta^B < \max[\frac{1}{2}, \Theta_1^{\text{MT}2}]$ , the NGO has full participation and separate standards, while the industry only certifies the low-cost firms. QED

When the certified market is large and low-cost firms have both a large cost advantage and a large market share, the industry may prefer to set a single ambitious standard that yields a high price. The NGO would introduce more competition into the certified market and would offer a multitier label instead. Thus, there exist situations in which the NGO will attract more participation than the industry in autarky.

#### 2.4.2. Implementing the Welfare Optimum

Finally, it is instructive to compare each of the sponsored schemes to the welfare-optimal set of standards. The most striking aspect of this comparison is that the industry association never implements the welfare-maximizing label structure. In sharp contrast, the NGO implements the welfare maximum under a wide range of parameter values. Both the NGO outcome and welfare optimum utilize the three possibilities of a single basic standard of  $\{s_E^B, s_E^B\}$ , a single ambitious standard of  $(s_E^A, 0)$ , and a multitier standard of  $(s_E^A - s_E^B, s_E^B)$ ; however, in some circumstances the welfare maximum calls for an intermediate multitier standard that is less stringent for the high-cost firms and more stringent for the low-cost firms. As a result, the parameter values for which the NGO chooses each label structure will not correspond exactly to the conditions for the welfare maximum. Nevertheless, a comparison of figures 2 and 4 shows that the NGO implements the welfare optimum in many cases. For example, when low-cost firms have a large enough share of the certified market, the NGO implements the socially optimal single ambitious standard. Similarly, when high-cost firms have a large enough share of the certified market but have a large cost disadvantage, the NGO implements the socially optimal multitier standard. Moreover, when high-cost firms have a large enough share of the certified market but have only a small cost disadvantage, the NGO implements the socially optimal single basic standard. Overall, there is considerable qualitative similarity between the NGO and the welfare-maximizing standards, in contrast to the industry optimum. We note this point in the following proposition.

**Proposition 4:** The industry never implements the welfare maximum. The NGO implements the welfare-maximizing set of standards when (a) low-cost firms have a large enough share of the certified market and have a relatively large cost advantage, (b) high-cost firms have a large enough share of the certified market but have a relatively large cost disadvantage, or (c) cost differentials are sufficiently small.

*Proof:* From previous propositions 1 and 2, when  $\theta^A/\theta^B < \min[\Theta_{\text{ICA}}, \Theta_W^{\text{MT}1}]$  and  $N^A/N < 1/2$ , both the planner and the NGO implement  $(s_{\text{ICA}}^A, s_E^B)$ . When

$\theta^A/\theta^B < \min[\Theta_W^{\text{Binary}}, \Theta_N^{\text{Binary}}]$  and  $N^A > N_W^A$ ,<sup>11</sup> both the planner and the NGO implement  $(s_E^A, 0)$ . When  $N < 2/3$ ,  $N^A/N < 1/2$  and  $\theta^A/\theta^B > \Theta_{\text{ICA}}$ , or when  $N < 2/3$ ,  $N^A/N > 1/2$  and  $\theta^A/\theta^B > \Theta_N^{\text{Binary}}$ , if the planner wishes to implement  $(s_E^B, s_E^B)$ , the NGO does as well. QED

### 3. LABEL COMPETITION

We turn now to the equilibrium of label competition.<sup>12</sup> The fact that the NGO and the industry association have not only different preferences but also different situations in which they would not offer a second label in autarky leaves room for label competition. Appendix B (available online) analyzes the case where labels are restricted to be binary. It shows that label competition can be beneficial for the environment when there is a large number of high-cost firms and they are at a significant cost disadvantage. As shown in the previous section, this is a situation in which a multitier standard is valuable, so if firms are for some reason constrained to offer only binary labels, competition can improve environmental outcomes.

Here we focus on the case when both label sponsors are able to offer multitier standards. Given the complexity of the results for the autarky cases, one might expect multitier label competition to produce extremely complicated results. However, exactly

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11. We show that  $N_W^A/N > 1/2$ :  $N_W^A = (\sqrt{1 + 2N - N^2/2} - 1)/N > 1/2$  if  $(\sqrt{1 + 2N - N^2/2})^2 > (N/2 + 1)^2$ , which holds since  $(2 + 4N - N^2)/2 - (N^2 + 4N + 4)/4 = N(1 - N/4) > 0$ .

12. Appendix B analyzes the case in which the two organizations compete subject to the constraint that each can offer only a binary ecolabel. This allows us to compare our results with those of Fischer and Lyon (2014), who study competition between binary labels under a different set of assumptions. The earlier paper differs from this one in two important ways. First, the previous paper used a representative consumer framework for the demand side of the model, while the present paper uses a vertical-differentiation framework based on heterogeneous consumers, as in Mussa and Rosen (1978). Second, the previous paper had a continuum of firms with varying costs of compliance, while the present paper has two types of firms differentiated by their cost of compliance. Despite the differences in assumptions, the basic results for binary label competition are qualitatively similar. First, there are two types of equilibria, a normal one in which the NGO offers a more ambitious standard than does the industry, and a reverse equilibrium in which the industry offers the more ambitious standard. Second, label competition sometimes offers better environmental performance than NGO autarky, especially if there is a large cost gap between high-cost and low-cost firms and there is a large number of high-cost firms. Under these conditions, a standard-setting entity faces a stark trade-off between extracting substantial improvements from low-cost firms and inducing participation by high-cost firms. Because it is impossible to accomplish both goals at once, label competition may be beneficial by setting a separate standard for each group of firms. An important difference between the two analyses, however, is that in the earlier paper, a normal equilibrium always exists, while in the present paper its existence depends upon parameter values.



the opposite turns out to be the case. Unlike autarky, where each organization's labeling scheme depends upon details of the parameters, we are able to show the striking result that under multitier label competition there is a single perfect equilibrium regardless of parameter values. Intuition might suggest that the industry association would be able to drive out the NGO label by setting standards that offer higher profits for both types of firms, but this turns out not to be the case.

**Proposition 5:** Under multitier label competition, the unique trembling-hand perfect equilibrium involves each player offering a multitier label of the form  $(s_\pi^A, s_\pi^B)$ .

*Proof:* See appendix A. QED

Proposition 5 provides the remarkable result that there is a unique equilibrium pair of standards under label competition, with each sponsor offering a multitier label, each tier of which maximizes profits for one industry segment or the other. With multitier label competition between an NGO and industry association, the only outcome that satisfies trembling-hand perfection is identical multitier labels set at the same levels as if there were two separate industry groups, one for each type of firm! This outcome is illustrated in figure 8.

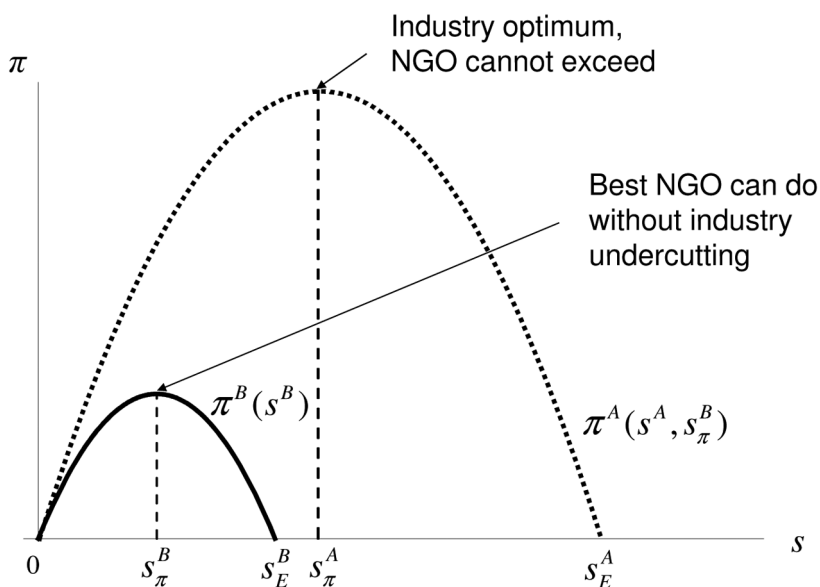


Figure 8. Unique equilibrium in multitier competition

This result is surely counterintuitive at first blush, at least for readers familiar with the certification industry. The fact that the equilibrium is driven almost entirely by industry profit-maximization considerations, rather than environmental protection, seems to run counter to casual empirical evidence that NGOs set tough standards that go beyond what industry prefers. However, the logic is clear and has two distinct components. First, the industry always sets its ambitious standard at the profit-maximizing level for the low-cost firms so it is impossible for the NGO to induce these firms to adopt any more stringent label. Second, the industry prefers to distort downward the basic standard in order to increase overall industry profits, a result familiar from the vertical differentiation literature (Shaked and Sutton 1982). Thus, competition from the NGO can raise the basic standard and improve environmental performance and it is impossible for the industry to induce these firms to adopt a weaker standard. In effect, the NGO sets a minimum quality standard that reduces the excessive product differentiation desired by the industry.<sup>13</sup> The fact that each sponsor offers a multitier label is then simply a response to the possibility of trembles by the other player. We discuss the implications of this result further in section 6.

#### 4. PARETO-IMPROVING COOPERATIVE SOLUTIONS

To this point we have focused solely on noncooperative solutions to the ecolabel game. Here we explore whether there may be cooperative outcomes that would be preferred by both players to the multitier equilibrium.

The question is whether there exists a  $s_C^A \neq s_\pi^A$  and  $s_C^B \neq s_\pi^B$  such that  $\Pi(s_C^A, s_C^B) > \Pi(s_\pi^A, s_\pi^B)$  and  $G(s_C^A, s_C^B) > G(s_\pi^A, s_\pi^B)$ . Consider an adjustment that holds environmental benefits constant:  $N^A s_\pi^A + (N - N^A) s_\pi^B = N^A s_C^A + (N - N^A) s_C^B$ . Thus, we solve for this  $s_C^B$  as a function of  $s_C^A$ :

$$s_C^B = \frac{(1 - N)(N - N^A) \frac{\theta^A}{\theta^B} + (1 - N^A) N^A}{2(N - N^A) \theta^A} - \frac{N^A}{(N - N^A)} s_C^A.$$

Maximizing profits  $\Pi(s_C^A, s_C^B(s_C^A))$  with respect to  $s_C^A$ , we get

$$s_C^A = \frac{(N - N^A) \frac{\theta^A}{\theta^B} + (1 - N^A) N^A}{2 \left( N^A + (N - N^A) \frac{\theta^A}{\theta^B} \right) \theta^A}.$$

Furthermore,

$$s_C^A - s_\pi^A = \frac{(N - N^A) N^A}{2 \left( N^A + (N - N^A) \frac{\theta^A}{\theta^B} \right) \theta^B} > 0$$

and

13. This result is similar to the analysis of minimum quality standards in Ronnen (1991).

$$s_{\pi}^B - s_C^B = \frac{(N - N^A)N^A}{2 \left( N^A + (N - N^A) \frac{\theta^A}{\theta^B} \right) \theta^B} > 0.$$

Because we have held environmental benefits constant, we know that  $s_C^B < s_{\pi}^B$ .

Therefore, there is room to raise total profits without lessening environmental gains (and vice versa). Both parties can do better by coordinating than engaging in a noncooperative multitier equilibrium. The result is more product differentiation than would occur in the noncooperative equilibrium and more environmental effort by the low-cost firms. We leave the details of a cooperative analysis for future research.

## 5. ENTRY

Suppose the number of firms in the certified market is not fixed, but rather determined by an entry decision that occurs after standards have been set. Suppose firms must incur a cost  $F$  to enter the certified market (e.g., the cost of an initial audit to ensure they meet the label's standards); they then find out what type of firm they are. With probability  $\alpha$  they will have cost  $\theta^A$  and with probability  $(1 - \alpha)$  they will have cost  $\theta^B > \theta^A$ . A firm will enter the market if its expected operating profits ( $\alpha\pi^{AA} + (1 - \alpha)\pi^{BB}$ ) exceed the entry costs; in other words, entry will occur until average operating profits equal  $F$ .

Since profits for low-cost firms certifying to the ambitious standard are always weakly higher than those of high-cost firms,<sup>14</sup> and thus strictly positive, the low-cost firms will always participate in their label after entering, assuming the standard satisfies the incentive compatibility conditions. But we must allow for the possibility that, after entry, not all high-cost firms will participate. Let  $\beta$  be the share of the available  $(1 - \alpha)N$  type B firms that, having entered, participate in the basic standard. Note that  $\beta = 1$  when  $\pi^{BB} > 0$  and when  $0 < \beta < 1$ ,  $\pi^{BB} = 0$ . The entry decision thus remains  $\alpha\pi^{AA} + (1 - \alpha)\pi^{BB} \geq F$ , but the equilibrium participation level is affected.

### 5.1. Entry Levels with Different Types of Standards

We begin our analysis by characterizing the extent of entry depending upon the structure of the labels that are offered in equilibrium.

#### 5.1.1. Single Basic Standard

If only a single basic label (SB) is offered, then high-cost firms are not shut out from the market and entry will occur as long as  $p^B - \alpha\theta^A(s^B)^2 - (1 - \alpha)\theta^B(s^B)^2 \geq F$ . Since  $p^B = s^B(1 - (\alpha + \beta(1 - \alpha))N)$ , in equilibrium, entry will lead to a total number of entrants

14. Otherwise they could defect to the weaker standard, where by definition they have higher profits than the high-cost firms; i.e.,  $\max\{\pi^{AA}, \pi^{AB}\} > \pi^{BB} \geq 0$ .

$$N_{SB} = \frac{s^B(1 - s^B\bar{\theta}) - F}{s^B(\alpha + \beta(1 - \alpha))},$$

where  $\bar{\theta} = \alpha\theta^A + (1 - \alpha)\theta^B$ . Given this amount of entry the price is  $p_{SB}^B = \bar{\theta}(s^B)^2 + F$ . Operating profits for type B firms in this equilibrium are then  $F - \alpha(\theta^B - \theta^A)(s^B)^2$  (regardless of  $\beta$ ). Thus, to sustain participation by any type B firms (i.e., for  $\pi^{BB} \geq 0$ ), we must have  $F \geq \alpha(\theta^B - \theta^A)(s^B)^2$ . This condition essentially places an upper bound on  $s^B$  being consistent with a single basic label equilibrium. If the inequality is strict, then all firms that have entered will participate ( $\beta = 1$ ).

Note that the numerator of  $N_{SB}$  is maximized at  $s^B = 1/(2\bar{\theta})$ , when it becomes  $1/(4\bar{\theta}) - F$ . Thus, if  $F > 1/(4\bar{\theta})$  then there is no entry to the single basic standard.

### 5.1.2. Single Ambitious Standard

In the case of a single ambitious standard (SA), which can only be met by low-cost firms, then  $p_{SA}^A = s^A[1 - \alpha N]$  and  $\pi_{SA}^A = s^A[1 - \alpha N] - \theta^A(s^A)^2$ . Since entry occurs until  $\alpha\pi^A = F$ , we obtain

$$N_{SA} = \frac{s^A(1 - s^A\theta^A) - F/\alpha}{s^A\alpha}.$$

Operating profits for type A firms are then  $\pi_{SA}^A = F/\alpha$ . Of course, demand limits the maximum possible operating profits. In the limit as  $N \rightarrow 0$ , the operating profits of a single entrant would be maximized at  $s^A = 1/(2\theta^A)$  and would be equal to  $\pi_{SA}^A = 1/(4\theta^A)$ . Thus, the single ambitious label cannot be supported if  $F > \alpha/(4\theta^A)$  because no entry will occur.

### 5.1.3. Multitier Standards

In the case of multitier basic and ambitious labels (M), prices are differentiated by type, and equilibrium operating profits must be nonnegative for both types. Thus, the relevant prices are  $p^B = s^B(1 - (\alpha + \beta(1 - \alpha))N)$ , and  $p^A = s^A(1 - \alpha N) - s^B\beta(1 - \alpha)N$ . Substituting in our expressions, the expected profits will equal the entry costs when

$$N_M = \frac{\bar{s} - \bar{c} - F}{\alpha\bar{s} + \beta(1 - \alpha)s^B}, \quad (6)$$

where  $\bar{s} = \alpha s^A + (1 - \alpha)s^B$  is the average standard and  $\bar{c} = (\alpha\theta^A(s^A)^2 + (1 - \alpha)\theta^B(s^B)^2)$  is the average compliance cost.

For the separating equilibrium, we can define a minimum and maximum entry fee that allows for an interior solution. First, from the expression for  $N_M$ , we see immediately that if  $F > F_{\max}^M \equiv \bar{s} - \bar{c}$ , there will be no entry and no certified market; this

constraint puts bounds on the possible standards. Second, if the fee is low enough, that is, if  $F \leq \alpha s^A (s^B \theta^B - s^A \theta^A) < F_{\max}^M$ , then excess entry to access the ambitious standard (because the profits are high enough and the probability of being an ambitious type high enough) can create excess supply of the basic standard, leading to  $\beta = 0$ .<sup>15</sup> In the subsequent analysis, for simplicity we will focus on equilibria where  $\beta = 1$ .

Because entry is endogenous, reference points such as  $s_\pi^A$  and  $s_E^A$  depend on  $N$ , which in turn depends on the standards themselves. Thus, to be fully explicit we could write  $s_\pi^A(N_{SA}(s_\pi^A)) = (1 - \alpha N_{SA}(s_\pi^A))/2\theta^A$  where the subscript SA indicates that we are considering the single ambitious label, which offers the greatest profits for type A firms. Similarly, we could write  $s_E^A(N_{SA}(s_E^A)) = (1 - \alpha N_{SA}(s_E^A))/\theta^A$  to indicate the highest standard that is consistent with the individual rationality constraint for the type A firms with a single ambitious label. To economize on notation, however, we will suppress this dependence below and simply write  $s_\pi^A$  and  $s_E^A$ . A key tool in the analysis is the response of total entry to changes in the standards:

$$\frac{\partial N_M}{\partial s^A} = \frac{\alpha(1 - 2\theta^A s^A - \alpha N_M)}{\alpha^2 s^A + (1 - \alpha^2)s^B} \quad (7)$$

and

$$\frac{\partial N_M}{\partial s^B} = \frac{(1 - \alpha)(1 - 2\theta^B s^B - (\alpha + 1)N_M)}{\alpha^2 s^A + (1 - \alpha^2)s^B}. \quad (8)$$

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15. In this case, equilibrium requires that only  $\beta(1 - \alpha)N$  firms participate in the basic standard, since otherwise operating profits would be negative. Hence, for  $\beta \in (0, 1)$ , we require  $s^B(1 - (\alpha + \beta(1 - \alpha))N) = \theta^B(s^B)^2$ , so that the operating profits of type B firms are just zero. Simplifying, we obtain

$$\beta = \frac{1 - \theta^B s^B - \alpha N}{N(1 - \alpha)}.$$

Substituting in for  $N_M$  yields

$$\begin{aligned} \beta|_{s_M^B=0} &= (1 - \alpha N_M - s^B \theta^B)/((1 - \alpha)N_M) \\ &= \left(\frac{\alpha}{1 - \alpha}\right) \frac{F - \alpha s^A (s^B \theta^B - s^A \theta^A)}{\alpha(s^A(1 - s^A \theta^A) - s^B(1 - s^B \theta^B)) - F}. \end{aligned}$$

Note that the denominator of this expression is positive when  $F < F_{\max}^{MB} \equiv \alpha(s^A(1 - s^A \theta^A) - s^B(1 - s^B \theta^B)) < F_{\max}^M$ . Next, from the numerator we see that if  $F \leq \alpha s^A (s^B \theta^B - s^A \theta^A) < F_{\max}^{MB}$ , then  $\beta = 0$ . In this situation, the cost differences are high enough and the fixed costs low enough that entry by ambitious firms drives the high-cost firms out of the certified market. Note that this is only possible if the basic standard is sufficiently high.

Note that for all  $s^A \geq s^B \geq 0$ ,  $\partial^2 N_M / \partial (s^A)^2 < 0$ , and a sufficient condition for  $\partial^2 N_M / \partial (s^B)^2 < 0$  is  $\partial N_M / \partial s^B|_{s^B=0} \geq 0$ .<sup>16</sup>

Analytical solutions to the autarky multitier standards in the presence of entry are too complex to derive usefully, although it is possible to characterize the outcomes and to conduct numerical explorations. Because our key result is the equilibrium of multitier competition, however, we focus on that in the remainder of the section.

## 5.2. Multitier Competition with Entry

The NGO's objective function is to maximize environmental gains, just as in prior sections. The industry trade association's objective requires a bit more consideration. One possibility would be for the industry association to maximize aggregate profits of firms net of the entry cost, but because net profits are always zero with entry, this would yield indeterminate results. Alternatively, the industry association could maximize total operating profits (i.e., contribution to fixed costs) of all member firms (i.e., those that have entered),  $N\bar{\pi}$ , or equivalently the total industry profits including the revenues of the certifiers, in which case  $F$  is merely a transfer. Because average operating profits per firm in equilibrium always equal  $F$ , maximizing member profits is tantamount to maximizing  $NF$ , or simply maximizing  $N$ . This approach yields determinate results and is the one we adopt here.

With entry, the industry still wants to maximize average profits, now in equilibrium as a way to maximize participation. Maximizing participation is achieved by setting (7) and (8) to zero, which yields  $s^A = s_\pi^A = (1 - \alpha N_M) / (2\theta^A)$  and  $s^B = (1 - (1 + \alpha)N_M) / (2\theta^B) = s_\pi^B - \alpha N_M / (2\theta^B)$ , just as in the earlier industry autarky analysis. Thus, the industry still wants to offer the profit-maximizing standard to the ambitious firms and would prefer a standard below the profit-maximizing standard for the basic firms. The NGO, however, wants to maximize total environmental gains and will not allow the basic standard to fall below the profit-maximizing standard for the type B firms.

Let  $\tilde{s} = \alpha^2 s^A + (1 - \alpha^2) s^B = \alpha \tilde{s} + (1 - \alpha) s^B$ . At  $s^B = s_\pi^B = (1 - N_M) / (2\theta^B)$  and  $\beta = 1$ ,  $\partial N_M / \partial s^B = (1 - (1 - N_M) - (\alpha + 1)N_M)(1 - \alpha) / \tilde{s} = -\alpha(1 - \alpha)N_M / \tilde{s} <$

16. Derivations reveal that

$$\frac{\partial^2 N_M}{\partial (s^A)^2} = - \frac{2\alpha(s^B(1 - \alpha)\alpha^2 + F\alpha^3 + (s^B)^2((1 - \alpha^2)^2\theta^A + (1 - \alpha)\alpha^3\theta^B))}{(\alpha^2 s^A + (1 - \alpha^2) s^B)^3} < 0$$

globally. Meanwhile,

$$\frac{\partial^2 N_M}{\partial (s^B)^2} = - \frac{(1 - \alpha)(F(1 + \alpha) + (s^A)^2\alpha(1 + \alpha)\theta^A - (s^B)^2(1 - \alpha^2)\theta^B - s^A\alpha(1 + 2s^B\alpha\theta^B))}{(\alpha^2 s^A + (1 - \alpha^2) s^B)^3},$$

which is negative if  $F \geq \alpha s^A([1/(1 + \alpha)] - s^A\theta^A)$ .

0, so  $s_\pi^B$  is indeed higher than the industry would prefer. The NGO's first-order condition with respect to  $s^B$  is  $(1 - \alpha)N_M + \bar{s}\partial N_M/\partial s^B = 0$ , or  $\partial N_M/\partial s^B = -(1 - \alpha)N_M/\bar{s}$ . It is easy to see that  $(1 - \alpha)N_M\alpha/\bar{s} < (1 - \alpha)N_M/\bar{s}$ , so  $\partial N_M/\partial s^B|_{s^B=s_\pi^B} > -(1 - \alpha)N_M/\bar{s}$ , meaning  $s_\pi^B$  is lower than the NGO would prefer. Therefore, the NGO would like a higher basic standard and the industry would like a lower one, and the best either can do to counter the other is to offer  $s_\pi^B$ . This gives us the same equilibrium strategy as without entry, which we record in the following proposition.

**Proposition 6:** With free entry, the competitive equilibrium with multitier standards is  $(s_\pi^A, s_\pi^B)$ .

Of course, the exact value of these standards depends upon the entry condition (6), itself a function of  $\alpha$  and  $F$ . The equilibrium solution yields:<sup>17</sup>

$$\begin{aligned}s^A &= \frac{(1 - 2\alpha^2 + \alpha^3)\theta^A + \alpha\sqrt{Z}}{2\theta^A X} \\ s^B &= \frac{\alpha(1 - \alpha)(\theta^A - \alpha\theta^B) + \sqrt{Z}}{2\theta^B X} \\ N_M &= \frac{(1 - \alpha^2)\theta^A + \alpha^2\theta^B - \sqrt{Z}}{X}\end{aligned}$$

where  $X = (1 + \alpha - 2\alpha^2)\theta^A + \alpha^3\theta^B > 0$  and  $Z = \theta^A(4F\theta^B X - (1 - \alpha)^2\alpha(\theta^B + \alpha(\theta^B - \theta^A)))$ . Thus, the result of proposition 5 continues to hold, but with  $s_\pi^A$  and  $s_\pi^B$  defined not by an exogenous  $N$ , but by  $F$  and  $\alpha$ .

## 6. DISCUSSION

Our model yields a rich set of testable predictions, along with some normative implications. We first analyzed the labeling strategies of NGO and industry label sponsors in autarky and showed that they differ substantially. First, the NGO sets more stringent binary standards than does the industry. Second, the industry prefers multitier labels in a wider range of situations than does the NGO. Third, the industry never sets a binary standard that can be met by all firms, but the NGO does so when the cost differential between firms is narrow and there are roughly the same number of high-cost and low-cost firms. Importantly, the industry never implements the welfare-optimal standard, but the NGO does so under quite a wide range of industry conditions. We then turned to label competition and showed that the equilibrium of multitier label competition takes a unique, robust form that is largely determined by industry preferences;

17. Calculations performed in Mathematica.

this equilibrium is robust to entry and always produces weaker environmental protection than would the NGO alone. Finally, we showed that there is room for cooperative agreements between NGO and industry sponsors that can simultaneously raise profits and improve environmental gains, relative to the competitive equilibrium. In this section, we discuss how these results map onto stylized facts about label competition.

As described by Conroy (2007) and modeled by Baron (2011), many certification systems sprang from campaigns by NGOs that attacked existing corporate practices and demanded higher standards. As first movers, these NGOs possessed market power in setting standards, as described by our analysis of NGO autarky. As our analysis of label competition demonstrates, however, these first movers lose considerable market power when confronted with entry by industry associations. Thus, theoretical models of ecolabels that ignore the role of competition are likely to provide quite an unrealistic picture that exaggerates the power of certification to shift markets.

An interesting possibility is that current outcomes in the ecolabel market are not consistent with being in a long-run equilibrium. In fact, it turns out that there are good reasons to suspect that the current ecolabel market is not in long-run equilibrium. According to [www.ecolabelindex.com](http://www.ecolabelindex.com), the number of ecolabels on offer has grown sharply over time, with 444 currently available in 197 countries and 25 industry sectors. Many commentators have decried this proliferation of labels, fearing that it leads to consumer confusion and a loss of faith in the whole ecolabeling enterprise. For example, the Organization for Economic Cooperation and Development (OECD) has held a series of meetings devoted to exploring solutions to the problems created by ecolabel proliferation.<sup>18</sup> Many observers have predicted that there will ultimately be consolidation in the ecolabel industry, just as there often is in other industries, but they have been at a loss to predict the form of the industry shakeout.<sup>19</sup> One reason that consolidation and equilibrium seem to be so slow in the ecolabel industry is that many label sponsors are nonprofits, whose motivations may lie more in maintaining their position in the market rather than seeking out profitable or efficient outcomes. Interestingly, the recent announcement of a merger between two major ecolabels, those of Rainforest Alliance and UTZ, may signal that a new phase of consolidation has begun (Kaye 2017).

Although our analysis is not explicitly dynamic, it provides some intriguing indications of how the ecolabel market may evolve over time. As shown in propositions 5 and 6, the unique multitier equilibrium in our model involves two standards, each set at the

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18. The OECD has also commissioned a series of white papers on ecolabel proliferation (Gruère 2013; Lyon 2014).

19. Heyes and Martin (2016) offer an interesting model in which ecolabels are differentiated both horizontally and vertically, which allows them to address the question of the equilibrium number of labels. Each label is binary and occupies a unique horizontal niche, however, so the issue of multitier competition does not arise in their model.



level that is profit maximizing for one group of firms. These are very much industry-driven outcomes, the only wrinkle being that there is somewhat more intense label competition than would be profit maximizing for the industry as a whole. We also showed that a cooperative arrangement can be Pareto improving, suggesting that consolidation and multi-stakeholder governance structures are likely to be part of any ultimate equilibrium. Interestingly, the apparel industry appears to have already evolved from a situation dominated by NGO labels to one dominated by business-led labels (Marques 2013). Concerns about sweatshop labor in the apparel industry were initially voiced in 1989 by an activist NGO, Clean Clothes Campaign (CCC). Over time, more and more organizations, both nonprofit and industry-driven, entered the space, to the point that by 2005 the CCC was stating publicly its concern that there were “too many multi-stakeholder initiatives” (Marques 2013, 26). In 2007, the Global Social Compliance Program (GSCP) was launched in an effort to harmonize the growing set of standards, and in 2013 Wal-Mart’s Sustainability Consortium launched a Clothing, Textiles, and Footwear working group to help drive convergence across standards in a way that was consistent with Wal-Mart’s goals, which can be assumed to be largely market driven.

There are signs of movement toward greater business domination within the realm of sustainability labels, as well. The US Green Building Council’s Leadership in Energy and Environmental Design (LEED), which offers certified, silver, gold, and platinum tiers, long held a monopoly position in building certification. It has attracted competition from the Green Globes certification scheme, an industry-led alternative that offers faster and less expensive certification than LEED (Alter 2013) and that is supported by US timber companies because it does not require FSC certification for lumber used in construction (Bach 2013). Green Globes is also a multitiered certification scheme, offering from one to four “globes” to participating buildings. A detailed comparison between the two systems is provided by Smith et al. (2006). Within the timber sector, there was some early evidence that the standards of the FSC and the SFI were gradually converging, as FSC became more market friendly and SFI attempted to incorporate more conservation concerns (Cashore et al. 2004). More current work suggests that the standards of both sponsors have been tightening over time, perhaps due to changes in preferences among consumers (Judge-Lord et al. 2015). Consistent with the predictions of our analysis, recent changes in the SFI label have essentially rendered it a multi-tier label by allowing users to specify any desired percentage of certified content they choose. In the coffee sector, there appears to be convergence among multiple different labels in terms of core criteria, but with some level of differentiation remaining as labels go after consumer groups with differing preferences (Reinecke et al. 2012).

Although it would be premature to claim that labeling schemes for any of these sectors have reached equilibrium, our results suggest that a plausible long-run outcome will be convergence toward business-led harmonized certification schemes, perhaps ul-

timately followed by a cooperative bargaining process that results in a single multi-stakeholder label.

## 7. CONCLUSIONS

We have developed the first theoretical model of competing multitier ecolabels. This is an important theoretical step, because although the literature has focused on labels that are binary in structure, some prominent labels, such as the US Green Building Council's LEED certification, have multiple tiers instead and all labels could potentially choose to have multiple tiers. We present a theory explaining how standard-setting organizations choose between these two forms and compare the differing incentives of industry trade associations and nongovernmental organizations (NGOs) in setting standards. We show that for either type of organization in autarky, multitier labels are more attractive when the number of low-cost producers is small and the cost gap between low-cost and high-cost firms is large. We show that the NGO operating in autarky implements the welfare-maximizing outcome for some, but not all, parameter values; the industry never does. When competition occurs using multitier labels there exists a unique equilibrium pair of standards, even with endogenous entry by producers, and competition always provides less environmental protection than would the NGO in autarky. Our results suggest that competition between ecolabels may involve mergers or cooperation between NGO and industry labels but that in equilibrium the standards reflected in these labels will be dominated by considerations of profitability as opposed to environmental protection.

## APPENDIX A

### Proof of Proposition 1

A social planner would choose  $s^A$  and  $s^B < s^A$  to maximize welfare  $W = CS + G + \Pi$  subject to the ICA constraint (assigned the shadow value  $\lambda_{ICA}$ ), the ICB constraint (assigned the shadow value  $\lambda_{ICB}$ ), and the IRB constraint that the basic standard cannot exceed  $s_B^E$  (shadow value  $\gamma_{IRB}$ ). The Lagrangian associated with the planner's problem is thus

$$\begin{aligned} \mathcal{L} = & ((N^B (2 - N - N^A))/2)s^B + ((N^A(2 - N^A))/2)s^A - N^A\theta^A(s^A)^2 \\ & - N^B\theta^B(s^B)^2 + N^A s^A + N^B s^B + \lambda_{ICA}((1 - N^A)/\theta^A - s^B - s^A) \\ & + \lambda_{ICB}(s^B - (1 - N^A)/\theta^B + s^A) + \lambda_{IRB}((1 - N)/\theta^B - s^B). \end{aligned}$$

The first-order conditions yield

$$s^A = (4 - N^A)/(4\theta^A) + (\lambda_{ICB} - \lambda_{ICA})/(2N^A\theta^A) \quad (A1)$$

and

$$s^B = (4 - N^B - 2N^A)/(4\theta^B) + (\lambda_{ICB} - \lambda_{ICA} - \gamma_{IRB})/(2N^B\theta^B). \quad (A2)$$

If  $\lambda_{ICA} = 0$ , then  $s^A \geq (4 - N^A)/4\theta^A$ . However, if the ICA constraint is to be met (even when it is least binding at  $s^B = 0$ ), we must have  $s^A \leq (1 - N^A)/\theta^A$ . For both conditions to hold therefore requires

$$\frac{(4 - N^A)}{4\theta^A} < \frac{1 - N^A}{\theta^A}.$$

This is never true, so the ICA constraint must be binding and  $\lambda_{ICA} > 0$ , implying we have  $s^A = s_E^A - s^B$ . Moreover, by lemma 1, the fact that the ICA constraint binds implies that the ICB constraint is not binding and  $\lambda_{ICB} = 0$ . Because  $\lambda_{ICB} = 0$  and the ICA binds we can write

$$\frac{(4 - N^A)}{4\theta^A} - \frac{\lambda_{ICA}}{2N^A\theta^A} = \frac{1 - N^A}{\theta^A} - \frac{(4 - N - N^A)}{4\theta^B} + \frac{\lambda_{ICA} + \gamma_{IRB}}{2N^B\theta^B}.$$

One potential equilibrium occurs when  $\gamma_{IRB} = 0$ , which implies  $s^B < s_E^B = (1 - N)/\theta^B$ . In this case there is a multitier equilibrium defined by

$$s^A = \frac{(4 - N^A)}{4\theta^A} - \frac{\lambda_{ICA}}{2N^A\theta^A}$$

and

$$s^B = \frac{(4 - N - N^A)}{4\theta^B} - \frac{\lambda_{ICA}}{2N^B\theta^B},$$

with

$$\lambda_{ICA} = \frac{3(N^A)^2\theta^B N^B + (4 - N - N^A)\theta^A N^A N^B}{2N\theta}.$$

A special case of this type of equilibrium occurs when  $s^B \leq 0$ , in which case the standard is  $\{s_E^A, 0\}$ .

If  $\gamma_{IRB} > 0$ , so that  $s^B = s_E^B = (1 - N)/\theta^B$ , then

$$s^B = \frac{(4 - N - N^A)}{4\theta^B} - \frac{\lambda_{ICA} + \gamma_{IRB}}{2N^B\theta^B} = \frac{1 - N}{\theta^B},$$

with

$$\lambda_{ICA} + \gamma_{IRB} = \frac{N^B(3N - N^A)}{2}.$$

Thus, another special case is  $s^A = s_E^A - s^B$  and  $s^B = s_E^B$ .

Finally, if  $s_E^A - s_E^B < s_E^B$  this would imply  $s^A < s^B$ , so in this case all firms certify to  $s_E^B = (1 - N)/\theta^B$ . This occurs if  $(1 - N^A)/\theta^A < 2(1 - N)/\theta^B$ , or  $\theta^A/\theta^B > (1 - N^A)/(2(1 - N))$ . Thus the three possible types of equilibria are (a)  $\{s_E^A - s^B, s^B\}$ , (b)  $\{s_E^A, 0\}$ , or (c)  $\{s_E^B, s_E^B\}$ .

Since there are only three types of equilibrium outcomes, we can characterize precisely the parameter values for which each type emerges. In the interior case of  $\{s_E^A - s^B, s^B\}$  with  $s^B \in (0, s_E^B)$ , welfare is

$$W(s_E^A, s^B) = \frac{N^A(1 - N^A)(2 + N^A)}{2\theta^A} + \left( \frac{N^B(4 - N^B - 2N^A) - 3(N^A)^2}{2} \right) s^B - (N^A\theta^A + N^B\theta^B)(s^B)^2.$$

The welfare-maximizing basic standard is then

$$s_W^B = \frac{N(4 - N) - 2N^A(2 + N^A)}{4N\bar{\theta}}.$$

This will violate the constraint that  $s^B \geq 0$  when  $N(4 - N) < 2N^A(2 + N^A)$ . The quadratic formula shows that this is equivalent to

$$N^A > N_W^A \equiv -1 + \frac{\sqrt{4 - 2N^2 + 8N}}{2}.$$

If  $N = 1/2$ , this implies  $N_W^A = .3693$  and  $N_W^A/N \geq .7386$ . If  $N = 2/3$ , we get  $N_W^A = .45297$  and  $N_W^A/N \geq .679455$ . For values of  $N^A/N$  greater than this threshold, an interior solution does not exist.

The expression for  $s_W^B$  will violate the constraint  $s^B \leq s_E^B$  when

$$\frac{\theta^A}{\theta^B} \leq \Theta_W^{\text{MT1}} \equiv \frac{3N^2 - 2N^A(N^A - 2N)}{4N^A(1 - N)}.$$

Thus, for  $\theta^A/\theta^B < \Theta_W^{\text{MT1}}$ , the optimum must be either  $(s_E^A - s_E^B, s_E^B)$  or  $(s_E^B, s_E^B)$ . Of course, when  $\theta^A/\theta^B > \Theta_{\text{ICA}} \equiv (1 - N^A)/(2(1 - N))$ , we have  $s_E^A - s_E^B < s_E^B$ , so the multitier standard is infeasible, but the single basic standard  $\{s_E^B, s_E^B\}$  is still available.

When  $\theta^A/\theta^B > \Theta_W^{\text{MT1}}$ , the interior solution is feasible, but it may be optimal to relax the ICA constraint and implement  $(s_E^B, s_E^B)$  instead. This occurs if  $\theta^A/\theta^B > \Theta_W^{\text{MT2}}$ , where the latter is defined by setting  $W(s_{\text{ICA}}^A(s_W^B), s_W^B) = W(s_E^B, s_E^B)$ .

On the region where both  $(s_E^B, s_E^B)$  and  $(s_E^A, 0)$  are feasible, it is necessary to directly compare welfare under the two standards. Some calculations show that  $W(s_E^B, s_E^B) > W(s_E^A, 0)$  if

$$\frac{\theta^A}{\theta^B} \left[ N + \frac{N^2}{2} + N^A(1-N)\left(1 - \frac{\theta^A}{\theta^B}\right) \right] > \frac{1-N^A}{1-N} \left[ N^A + \frac{(N^A)^2}{2} \right],$$

and equality obtains at  $\theta^A/\theta^B = \Theta_W^{\text{Binary}}$ . QED

### Proof of Proposition 2

From the NGO's perspective, the multitier standard dominates the single ambitious standard when  $N^A(s_E^A - s_E^B) + N^B s_E^B > N^A s_E^A$ , or simply when  $N^A < N/2$ . Thus, when the low-cost firms have more than half of the labeled market share, the NGO does not wish to water down the ambitious standard to accommodate a positive basic standard.

The multitier standard dominates the single basic one when  $N^A(s_E^A - s_E^B) + N^B s_E^B > N s_E^B$ , or  $s_E^A - s_E^B > s_E^B$ . Note that this is equivalent to  $s_\pi^A > s_E^B$ . As in the welfare maximization, this means that the cost gap between the two types of firms must be sufficiently large, that is

$$\theta^A/\theta^B < \Theta_{\text{ICA}} = (1 - N^A)/2(1 - N). \quad (\text{A3})$$

Note that  $\Theta_{\text{ICA}} \geq 1/2$  because  $N^A \leq N$ , and that  $\Theta_{\text{ICA}} \geq 1$  when  $N \geq (1 + N^A)/2$ . In this latter case, with the basic standard at  $s_E^B$  the NGO can always find a higher standard that the low-cost firms will accept.<sup>20</sup>

The single ambitious standard dominates the single basic one when  $N^A s_E^A > N s_E^B$ , or when

$$\theta^A/\theta^B < \Theta_N^{\text{Binary}} \equiv \frac{N^A(1 - N^A)}{N(1 - N)}. \quad (\text{A4})$$

Thus, when the low-cost firms have more than half of the certified market, and the cost gap is large enough, the single ambitious standard dominates both the multitier and the single basic standard. Note that  $\Theta_N^{\text{Binary}} = \Theta_{\text{ICA}}$  when  $N^A/N = 1/2$ , and  $\Theta_N^{\text{Binary}} > \Theta_{\text{ICA}}$  when  $N^A/N > 1/2$ . Moreover,  $\Theta_N^{\text{Binary}} \geq 1$  when  $N^A/N \geq 1/2$  and  $N \geq 2/3$ .<sup>21</sup> Since  $s_E^B > s_\pi^A$  was the condition for the basic standard to dominate the

20. Note that when  $N > 1/2$ , the right-hand side of (A3) is greater than unity for small values of  $N^A$  which means that the multitier standard is preferred to the single basic standard regardless of the cost gap when the number of low-cost firms is small enough.

21. Note that  $\Theta_N^{\text{Binary}}$  is concave in  $N^A$ , is equal to unity at  $N^A = N$  and  $N^A = 1 - N$ , and is strictly greater than unity for  $N^A$  between  $1 - N$  and  $N$ . Thus, if  $N > 1 - N$ , i.e., if  $N > 1/2$ , then for all  $N^A > 1 - N$ ,  $\Theta_N^{\text{Binary}} > 1$  and thus  $\theta^A/\theta^B < \Theta_N^{\text{Binary}}$ . When  $N > 2/3$ ,  $N^A > 1/3 = N/2$  implies  $\Theta_N^{\text{Binary}} > 1$ . (Since  $N^A \leq N$ , there are two cases to consider. If  $N < 1 - N$ , i.e., if  $N < 1/2$ , then  $\Theta_N^{\text{Binary}}$  rises monotonically in  $N^A$  reaching a maximum of unity when  $N^A = N$ . On the other hand, if  $N > 1 - N$ , i.e., if  $N > 1/2$ , then as  $N^A$  increases from zero,  $\Theta_N^{\text{Binary}}$  rises monotonically from zero to unity at  $N^A = 1 - N$  and remains greater than unity for all  $N^A \in (1 - N, N)$ . In this case,  $\theta^A/\theta^B < N^A(1 - N^A)/(N(1 - N))$  for all  $N^A > 1 - N$ .)

multitiered one,  $s_E^B > s_\pi^A$  is a necessary condition to warrant a single basic standard. QED

### Proof of Proposition 3

The industry's problem is to maximize the Lagrangian consisting of the industry objective function plus the two relevant constraints: the ICB constraint (assigned the shadow value  $\lambda_{ICB}$ ), and the constraint that the basic standard cannot be negative (shadow value  $\phi$ ):

$$\mathcal{L} = N^A \left( s^A(1 - N^A) - s^B N^B - \theta^A (s^A)^2 \right) + N^B \left( s^B(1 - N) - \theta^B (s^B)^2 \right) - \lambda_{ICB}((1 - N^A)/\theta^B - s^A - s^B) + \phi s^B.$$

Solving the first-order condition for the ambitious standard shows that

$$s_I^A = s_\pi^A + \frac{\lambda_{ICB}}{2\theta^A N^A} \geq s_\pi^A.$$

Solving the first-order condition for the basic standard, including the nonnegativity constraint, shows that

$$s_I^B = s_\pi^B - \frac{N^A}{2\theta^B} + \frac{(\lambda_{ICB} + \phi)}{2\theta^B N^B}.$$

Consider first the case where the ICB constraint is not binding, so  $\lambda_{ICB} = 0$ . Then the basic standard is set lower than would be profit-maximizing just for the high-cost firms, because raising it lowers prices for the low-cost types. Let us define the basic standard that would prevail in an interior solution ( $\phi = 0$  and  $\lambda_{ICB} = 0$ ) as

$$s_{Int}^B \equiv s_\pi^B - N^A/2\theta^B.$$

If  $N^A < 1 - N$  (i.e., if the type A market share is smaller than the share of consumers not purchasing a certified product),  $s_{Int}^B > 0$ . However, if  $N^A > 1 - N$ , then  $s_\pi^B - N^A/2\theta^B < 0$  which means that  $\phi > 0$ , and  $s^B = 0$ .

Now, consider the case where the incentive compatibility constraint is binding for the high-cost firms, so  $\lambda_{ICB} > 0$  and  $s^B = s_{ICB}^B$ . Since  $s_{ICB}^B \leq s_\pi^B$ , we know now that in all cases the industry wants to hold the high-cost firms to a lower standard than would maximize their individual type profits.

Next, we analyze the conditions under which the ICB constraint binds. To solve for the shadow value of the constraint, we set the optimal basic standard equal to the incentive-compatible basic standard, evaluated at the optimal ambitious standard:  $s_I^B = s_{ICB}^B(s_\pi^A + [\lambda_{ICB}/2N^A\theta^A])$ , or

$$s_\pi^B - \frac{N^A}{2\theta^B} + \frac{(\lambda_{ICB} - \phi)}{2\theta^B N^B} = (1 - N^A)/\theta^B - s_\pi^A - \frac{\lambda_{ICB}}{2\theta^A N^A},$$

which leads to

$$\lambda_{ICB} = \frac{N^A N^B}{N^B \theta^B + N^A \theta^A} ((1 + N^B) \theta^A - (1 - N^A) \theta^B) + \frac{N^A \theta^B}{N^B \theta^B + N^A \theta^A} \phi.$$

We noted above that if  $N^A < 1 - N$ , then the industry offers the high-cost firms a positive standard. Solving for  $\lambda_{ICB} = 0$  when  $\phi = 0$ , we find that the ICB constraint binds if

$$\frac{\theta^A}{\theta^B} > \Theta_I^{MT1} \equiv \frac{1 - N^A}{1 + N^B}. \quad (A5)$$

In this case, inequality (A5) simply determines whether or not the multitiered standard adds the shadow value of the ICB constraint to the interior solution.

However, if  $N^A > 1 - N$ , then  $s_{Int}^B < 0$ , and the constraint that  $s^B \geq 0$  will bind if the shadow value  $\lambda_{ICB}$  is not large enough on its own. In this case, as with the binary standard problem, as long as  $\phi > 0$ , the industry chooses  $\max[s_\pi^A, s_x^A]$ . To explore this range of possibilities, recall that the ICB constraint binds if at  $s_\pi^A, s_{ICB}^B > 0$ . Substituting, we obtain

$$s_{ICB}^B(s_\pi^A) = (1 - N^A)/\theta^B - s_\pi^A = \left(\frac{\theta^A}{\theta^B} - \frac{1}{2}\right)s_E^A.$$

We see immediately that if the ambitious firms have very low relative costs ( $\theta^A/\theta^B < 1/2$ ), then  $s_{ICB}^B < 0$  and the constraint that  $s^B \geq 0$  is the only one binding; in this case, the industry chooses a single standard of  $s_\pi^A$ . On the other hand, if the costs of the two firm types are more similar ( $\theta^A/\theta^B > 1/2$ ), then the ICB constraint binds; however, the constraint that  $s^B \geq 0$  may also bind. Even with a positive  $\lambda_{ICB}$ , the industry may still want a negative  $s^B$  to create more separation between the standards; if it is constrained from doing so, it will choose instead to raise  $s^A$  alone to meet the ICB requirement, before offering multitiered standards. In this case, the industry chooses  $s_x^A$ .

Finally, as the ICB constraint becomes more binding and the shadow value  $\lambda_{ICB}$  rises, we arrive again in the region where  $s^B > 0$ , so  $\phi = 0$ , and we have the multitier solution  $\{s_I^A, s_{ICB}^B\}$ . To solve for this border, we set  $s_x^A = s_I^A$ , evaluated at the equilibrium value of  $\lambda_{ICB}$ ; that is,

$$(1 - N^A)/\theta^B = s_\pi^A + \frac{\lambda_{ICB}}{2N^A\theta^A} = \frac{N(1 - 2N^A + N)}{2(N^A\theta^A + N^B\theta^B)}.$$

Solving for the cost ratio, we find that (for  $N^A > 1 - N$ ) the multitier solution occurs when

$$\frac{\theta^A}{\theta^B} > \Theta_I^{MT2} \equiv 1 - \frac{N(1 - N)}{2(1 - N^A)N^A}. \quad (A6)$$

Note that  $\Theta_I^{MT2} > \Theta_I^{multi}$  only when  $N^A > 1 - N$ . QED

### Proof of Proposition 5

Proposition 3 shows that the industry in autarky always sets  $s^A \geq s_\pi^A$ , with the equality holding unless either the IRB or the ICB constraint is binding. When the IRB binds, the industry prefers to set  $(s_\pi^A(0), 0)$ . However, the NGO's best response is then to set  $s^B > 0$ , in which case the IRB constraint no longer binds. When the ICB constraint binds, this is because the industry is distorting  $s^B$  downward to inflate profits for the low-cost firms. However, the NGO's best response is to offer  $s^B \geq s_\pi^B$ , which is more attractive to the type B firms and also offers more abatement. Thus neither the IRB nor the ICB constraints will bind in competitive equilibrium, and hence the industry will set in equilibrium set  $s^A = s_\pi^A$ . Since  $s_\pi^A$  maximizes the profits of the low-cost firms, the industry will always undercut the NGO's ambitious standard with  $s_\pi^A$ , and the NGO will not be able to attract the low-cost firms away; if the NGO offers an ambitious standard,  $s_\pi^A$  is the best it can do.

Proposition 3 also shows that the industry in autarky always sets  $s^B < s_\pi^B$  to maintain profits for the low-cost firms. Thus, the NGO can raise the standard for the high-cost firms to at least  $s_\pi^B$ , and the industry can do nothing to attract those firms away. Nor can the NGO go higher than  $s_\pi^B$ , because then the industry could attract the high-cost firms away with a lower standard. Furthermore, since  $s_\pi^A$  is the profit-maximizing standard for the low-cost firms regardless of  $s^B$ , even with a higher  $s^B$  than the industry would like, the industry has no incentive to further raise  $s^A$  to differentiate the products.

How the outcome is implemented—that is, exactly which label each sponsor offers—is more subtle. One possibility is that the two sponsors offer identical multitier labels. This equilibrium is robust to “trembles” in the sense of Selten (1975). If the industry makes a small deviation from  $s_I = (s_\pi^A, s_\pi^B)$  to play  $(s_\pi^A - \varepsilon, s_\pi^B - \mu)$ , the NGO's best response for  $\varepsilon > 0$  and/or  $\mu > 0$  is to offer  $s_N = (s_\pi^A + \varepsilon, s_\pi^B + \mu)$  and for  $\varepsilon < 0$  and/or  $\mu < 0$  the NGO's best response is to offer  $s_N = (s_\pi^A + |\varepsilon|, s_\pi^B + |\mu|)$ . Either way, as  $\varepsilon \rightarrow 0$  and  $\mu \rightarrow 0$ , the NGO's best response converges to the equilibrium value.

Similar logic applies for the industry's best response. If the NGO makes a small deviation from  $s_I = (s_\pi^A, s_\pi^B)$  to play  $(s_\pi^A - \varepsilon, s_\pi^B - \mu)$ , the industry's best response for  $\varepsilon > 0$  and/or  $\mu > 0$  is to offer  $s_N = (s_\pi^A, s_\pi^B - \mu)$  and for  $\varepsilon < 0$  and/or  $\mu < 0$  the industry's best response is to offer  $s_N = (s_\pi^A, s_\pi^B + \mu)$ . Either way, as  $\varepsilon \rightarrow 0$  and  $\mu \rightarrow 0$ , the industry's best response converges to the equilibrium value.

An alternative is that the industry offers only the ambitious standard and the NGO offers the basic standard, but this equilibrium is not robust to trembles. If the industry makes a small deviation from  $s_I = (s_\pi^A, 0)$  to play  $(s_\pi^A - \varepsilon, 0)$ , the NGO's best response is to offer  $s_N = (s_\pi^A + \varepsilon, s_\pi^B)$ . As  $\varepsilon \rightarrow 0$ , the NGO's best response does not converge to  $s_N = (0, s_\pi^B)$ . Similar logic applies for the industry's best response.

One might also think that it would be an equilibrium for the NGO to set the ambitious standard  $s_\pi^A$  and the industry to set the basic standard  $s_\pi^B$ , but this also does not survive the equilibrium refinement of trembling-hand perfection. Suppose the NGO



makes a small deviation from playing  $s_N = (s_\pi^A, 0)$  to play  $(s_\pi^A + \varepsilon, 0)$ . The industry's best response is to offer  $s_I = (s_\pi^A, \max\{0, s_{Im}^B, s_{ICB}^B\})$ . Furthermore, even as  $\varepsilon \rightarrow 0$ , the industry's best response remains  $(s_\pi^A, \max\{0, s_{Im}^B, s_{ICB}^B\})$  and never converges to  $(0, s_\pi^B)$ . On the other hand, if the industry makes a small deviation from  $s_I = (0, s_\pi^B)$  to play  $(0, s_\pi^B - \varepsilon)$ , the NGO's best response is to offer  $s_N = (s_{ICA}^A, s_\pi^B + \varepsilon)$ . Again, the NGO's best response does not converge to  $(s_\pi^A, 0)$  even as  $\varepsilon \rightarrow 0$ . QED

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